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A study of waste oil as an energy alternative for the University of Kansas

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A STUDY OF WASTE OIL AS AN ENERGY ALTERNATIVE FOR K.U.

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WASTE OIL

AS AN

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FOR THE

UNIVERSITY OF KANSAS

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SECTION I

CONCLUSIONS

After an extensive review of the current literature and interviews with government and industry people concerned with waste oil, the authors made projections for waste oil volumes to the year 2000. The topics of collectable amounts, price, and waste oil legislation were addressed.

The authors conclude that sufficient quantities of waste oil are available to meet the University of Kansas requirements for supplemental fuel. The University can buy the waste oil from established collectors in Topeka and Kansas City, who currently collect in the counties around K.U. The option also exists for K.U. to use oil donated in a community recycling program.

The price of waste oil fluctuates widely but is generally seen to be increasing. This is primarily due to the increasing price trend of other petroleum products (fuel oil and base lube oil blending stock). The storage capacity of K.U. will dictate to what extent it can take advantage of price fluctuations and recycling programs.

The authors also conclude that even though waste oil prices will be increasing, they will remain below the price of fuel oil. Thus waste oil as a supplemental fuel should be compared to non-petroleum alternatives (e.g. wood or coal) in order to make the most economically sound decisions.

A tremendous growth in the re-refining industry is seen as the only thing that could reduce the amount of waste oil

available as fuel. Key legislation is pending (e.g. H.R. Bill 6011) that could spark this growth, and it should be monitored accordingly.

SECTION II

INTRODUCTION

This project was undertaken to answer the questions: (1) how much waste oil will be available? and (2) what will it cost the University of Kansas to use it as a supplementary fuel in the proposed trash burning steam plant?

To answer these questions, the authors performed an extensive review of the current literature and conducted interviews with officials in the Kansas government and industry, who are involved in some way with waste oil. (A list of references is contained in the bibliography.) Although the primary focus is on Douglas, Franklin, and Jefferson counties, data for the State of Kansas and the United States were collected to prevent gross inaccuracies when using national projections to predict the local future growth. The historical data is limited to the years 1960-1975; projections were made to the year 2000. The motivating force for this project is the feasibility study that is being undertaken of a trash burning steam plant as a possible alternative to the current University of Kansas steam plant.

"The central steam plant of the Lawrence campus of the University of Kansas is supplied with interruptable natural gas and has oil standby capability. The relatively mild winters of the last few years have resulted in minimum gas interruption, less than 1% in 1975" (W.P. Smith, 1976, p. 1). During 1975 the total natural gas supplied to the Lawrence campus was 662,174 MCF. This natural gas provided a total

of 1814 MMBtu/day distributed between the central steam plant, residence halls and other buildings. The average cost was 66¢/MMBtu (W.P. Smith, 1976, p. 1). However, there are serious problems projected for the future relating to the availability and the cost of natural gas and fuel oil.

Natural gas has become a premium fuel and, until the removal of federal price controls, it will provide a cheap source of Btu's. It is clean and requires a very simple furnace for its consumption (Fowler, 1975, p. 79). "The future of natural gas is, however, uncertain. Domestic supplies are limited and natural gas shortages in 1971 were the first indicators of the energy crisis" (Fowler, 1975, p. 79). According to the National Petroleum Council's Committee on U.S. Energy Outlook, there are 1875 trillion cubic feet of ultimate discoverable gas. Assuming a recovery efficiency of 80% we can expect to obtain about 1500 trillion cubic feet which at the rate of consumption of 4.5% per year characteristic of the 1960-1970 period, this resource would last 22.5 years (Fowler, 1975, P. 279 & 280).

Future use of fuel oil has its problems too. The United States production of oil has not kept pace with the demand and the U.S. becomes more and more dependent on imports. "With the exception of the North Slope discovery in Alaska, the ratio of reserves to production has been steadily dropping. For whatever reason - lack of investment money, increasing difficulty of new drilling or the like - the inadequacy of domestic supplies has arisen in part, at least, because the oil companies have not been looking for oil with sufficient

intensity" (Fowler, 1975, p.278 & 279). At the same time, the price of fuel oil has risen sharply in the last several years, e.g. home heating oil has risen from 18¢/gal in 1970 to 39¢/gal in 1975 (Changing Times, July 1976, p.4) and the wholesale price of heavy fuel oil has gone from 6.14¢/gal in 1970 to 22.03¢/gal in 1975 (N.P.N. Factbook, 1976, p.83).

On the Lawrence campus, the problem is to decide what fuel should be used during the next twenty-five years, when some combination of increased price and decreased availability of the gas and oil cause the present steam plant to be prohibitively expensive. One alternative is to build a new coal fired steam plant. This would be a very expensive installation. The initial cost is estimated to be thirteen million dollars with the annual cost of coal over a million dollars (W.P. Smith, 1976, p.1). The University would be competing with the rapidly growing demand for coal by the electric utilities, and this use of coal is expected to continue to grow even into the "Nuclear era" (Fowler, 1975, p.73). When you consider the uncertainty of a coal supply in the future, as well as the cost, the disadvantages of this alternative appear substantial indeed (W.P. Smith, 1976, p.1).

"A much more attractive solution is to use energy sources presently available in the City of Lawrence and the surrounding territory which are not now being put to any productive use. These resources are solid waste, waste oil, and wood" (W.P. Smith, 1976, p.1). A 200-300 ton/day solid waste steam plant located adjacent to campus has been proposed and is presently being studied as to its feasibility. The primary fuel for

this steam plant would be solid waste with waste oil and wood used as supplemental fuels. This plant would be fed with solid waste generated by the three county area of Douglas, Franklin and Jefferson counties. The estimated population of the three county area for 1974 is 89,260 with an estimated solid waste generation of 206 tons/day, which appears to meet the average Lawrence campus steam needs (W.P. Smith, 1976, p.2).

Wood and waste oil would be used as a supplementary fuel for winter peak steam requirements. There are several possible sources of wood which could be used as fuel including urban tree removal, timber harvest, and tree plantations. An estimated 1100 tons of trees were removed in Lawrence during 1975 for a total energy supply of 13,000 MMBtu. Removals should continue but will decline at 10-12% each year. Another viable source of wood is a tree plantation. With optimization of species, harvest cycle, etc. a tree plantation might result in a yield of 110 MMBtu/acre/year and the plantation size necessary for K.U. reduced to 400-500 acres (W.P. Smith, 1976, p.2).

Another alternative supplemental fuel is waste oil. It has advantages of high Btu content with more convenient storage and handling characteristics. In periods of maximum steam demand (during the winter) waste oil could represent as much as one-third of the Btu input to the plant (W.P. Smith, 1976, p.1).

In this report, the waste oil alternative is studied, particularly in regard to local availability and cost.

Section III, Waste Oil Summary, examines the composition, generation and disposal problems of waste oil in the United States today. Section IV gives a summary of the re-refining situation in the United States and in Kansas. Section V looks at proposed waste oil legislation and its impact on waste oil use as a fuel. In Section VI the authors examine population, motor vehicle registrations and lube oil demand trends and from this data make their projections of waste oil volumes in the U.S., Kansas and the three counties of concern. In Section VII, drawing on the information discussed in earlier sections, the authors evaluate the economics of waste oil as an energy alternative for the University of Kansas.

SECTION III

WASTE OIL SUMMARY

Waste oils are lubricant oils which have collected contaminants during use of the oil. Waste oil lubricants are composed of a heterogeneous group of oils. They can be classified into three broad categories: Automotive, industrial and aviation, and other waste oils. Automotive waste oil includes crankcase oil (greater than 90%), transmission fluids, differential gear lubricants, hydraulic oils and small quantities of solvents frequently used in servicing automotive equipment. In the specific case of waste automotive crankcase oils, they might contain some or all of the following substances:

(1) a moderate amount of sulfur which is present in lubricating oils,

(2) many different oil additives, (synthetic organic chemicals that frequently contain sulfur, nitrogen, oxygen and metals). Some motor oil formulations contain sophisticated additive packages, representing the blending of between 15 and 20 additives,

(3) metallic particles such as iron which result from engine fretting and wear,

(4) gasoline, combustion products, atmospheric dust and oxidized materials and metals, transferred to the oil via piston blowby,

(5) sedimentary materials, products formed by internal engine deposits,

(6) water and other contaminants introduced into waste oil storage tanks (Chansky, 1974, p.48).

Lead is the principal metallic contaminant found in waste automotive oils and sometimes its concentration is higher than 1% by weight. As the use of unleaded gasoline is increased, it is expected that the concentration of lead in waste automotive oil will decrease (F.E.A., 1975, p.3).

A typical analysis of waste automotive oil is shown in Table 1 (U.S. E.P.A., 1974, p.14). In addition to the metals noted in the table there are a large number of other trace metals, including Al, Cu, Si, Sn, Na, and Mg (U.S. E.P.A., 1974, p.12). Additional properties typical of waste automotive oil are shown in Table 2 (U.S. E.P.A., 1974, p.17).

Industrial and aviation waste oils consist of many types of oils and emulsions used in the lubrication of industrial equipment, hydraulic and circulating systems, turbine lubrication and aircraft engine overhaul facilities.

In the "other" category are oils which have been used in transformers and refrigeration equipment and all the other equipment not included in the first two classifications (U.S. E.P.A., 1974, p.5). As a matter of comparison, a detailed characterization of some properties of waste oil lubricants, virgin fuel oil and virgin coals are shown on page A-11. (Chansky, 1974, p. 49 & 50)

The amount of waste oil which is generated is a function of demand or sales. In 1973 approximately 2.7 billion gallons of lubricating oil were sold in the United States generating an estimated 1.35 billion gallons of waste oil. In order to

TABLE 1

TYPICAL COMPOSITION OF WASTE AUTOMOTIVE OIL*

VARIABLE	VALUE
Gravity, ^{o}API	24.6
Viscosity @ 100^{o}F	53.3 Centistokes
Viscosity @ 210^{o}F	9.18 Centistokes
Flash Point	215^{o}F (C.O.C. Flash)
Water, (by distillation)	4.4 Volume %
BS & W	0.6 Volume %
Sulfur	0.34 Weight %
Ash, Sulfated	1.81 Weight %
Lead	1.11 Weight %
Calcium	0.17 Weight %
Zinc	0.08 Weight %
Phosphorous	0.09 Weight %
Barium	568 ppm**
Iron	356 ppm**
Vanadium	5 ppm**

* U.S. E.P.A., 1974, p.14

** ppm = parts per million

TABLE 2

SELECTED PROPERTIES OF USED AUTOMOTIVE LUBRICATING OILS*

PROPERTY	AVERAGE	RANGE
Specific Gravity	0.917	0.896-0.965
Viscosity @ 100°F SUS	436.000	267-753
Carbon Res. Conradson	6.5	3.8-12.6
Ash, %	2.49	1.57-3.78
Bomb Sulfur, Wt. %	0.44	0.26-0.52
Neutralization No.	6.67	4.00-14.26
Benzene Insolubles, %	2.0	1.17-3.33
BS & W, %	6.3	3.2-9.3

* U.S. E.P.A., 1974, p.17

convert automotive lube sales information to waste oil quantities, some factors have been developed. They are shown in Table 3 (U.S. E.P.A., 1974, p.10). Estimates for sales and waste oil are shown in Table 4 (U.S. E.P.A., 1974, p.11). Trends in domestic lube demand are shown on page A-1. Further analysis in relationships using these figures will be made later in this report.

The Federal Energy Administration's estimate of the ultimate fate of the generated waste oil is 43% used as fuel, 18% used as road oil or asphalt, 8% re-refined, and 31% including the re-refining wastes is unknown (F.E.A., 1975, p.4). The Environmental Protection Agency's estimate is shown in Table 5 (U.S. E.P.A., 1974, p.25). Assuming the validity of the 1973 estimated volume of waste oil, approximately 650 million gallons of waste oil are discharged directly to the environment each year by different methods such as road oiling, dust control, weed control, or indiscriminate dumping in water ways, municipal sewers or land surfaces (F.E.A., 1975, p.4). Some of these methods have been studied. In the case of road oiling for dust control, in a study carried out at the EPA's Water Quality Research Laboratory at Edison, N.J. it was estimated that after a period of 12 years, 99% of all oil applied on the road surface had left the road surface either in water runoff, dust particles, or volatilized (F.E.A, 1975, p.4).

The number of people who change their own oil, buying the oil at retail stores, has been growing. In 1961, service stations accounted for about 70% of all sales of lube oil for

TABLE 3

ESTIMATE OF FACTORS FOR CONVERTING AUTOMOTIVE SALES TO WASTE OIL QUANTITIES*

<u>SERVICE STATIONS</u>

70% of oil sold is used for changes.

Oil drained is 90% of filled capacity.

70% x 90% = 63% of oil sold = waste oil generated.

<u>GARAGES and AUTO SUPPLY STORES</u>

Assume average is same as service stations (63%).

<u>NEW CAR DEALERS</u>

100% of oil sold is used for changes.

Oil drained is 90% of filled capacity.

100% x 90% = 90% of oil sold = waste oil generated.

<u>AUTOMOTIVE FLEET and OTHER LUB OIL USERS</u>

Assume 50%, allowing for two-cycle engines and internal use, e.g. fuel, by commercial & governmental fleets.

<u>OIL BOUGHT AT DISCOUNT STORES</u>

Assume same as service stations (63%).

Assume 35% of waste oil generated finds its way to service stations.

63% x 35% = 22% of oil sold = waste oil generated at service stations.

<u>RETAIL SALES FOR COMMERCIAL ENGINES</u>

Assume same as service stations (63%).

* U.S. E.P.A., 1974, p.10

TABLE 4

WASTE OIL GENERATION (1972)*

(millions of gallons)

	SALES	W.O. FACTOR	WASTE OIL
AUTOMOTIVE LUBE SALES			
Service Stations	270	.63	170
Garages, auto supply stores	60	.63	38
New car dealers	102	.90	92
Retail sales for commercial engines	90	.63	57
Auto fleet & other uses	136	.50	68
Factory fills (auto & farm)	60	.90	54
Discount stores	168	.22	37
Commercial engine fleets	200	.50	100
	1086		616 **
INDUSTRIAL and AVIATION LUBE OILS			
Hydraulic & Circulating system oils	325	.42	137
Metal working oils	150	.42	105
Railroad engine oils	60	.53	32
Gas engine oils	62	.90	56
Aviation & other	137	.50	64
	734		394
OTHER INDUSTRIAL OILS			
Process oils	310	.10	31
Electrical oils	57	.90	51
Refrigeration oils	10	.50	5
	377		87
LUBE OILS PURCHASED BY U.S.	37	.50	18
GRAND TOTALS	2234		1115

* U.S. E.P.A., 1974, p.11.

** Other national estimates range from 400 to 730.

TABLE 5

GENERATION, DESTINATION, AND DISPOSAL OF WASTE OILS (1972) *

(millions of gallons)

CATEGORY	GENERATED WASTE OIL	TO REPROCESSORS	TO RE-REFINERS	ROAD OILS ASPHALTS	FUEL	OTHER
Automotive	616	202	105	142	19	148
Industial and Aviation	394	130	16	25	111	112
Other Industrial	87	28	3	6	25	25
U.S. Government	18	4	3	4	4	3
TOTAL	1115	364	127	177	159	288
Reprocessed Oils		-364		36	310	18
Re-refinery Waste			-41		10	31
ULTIMATE DISPOSAL		0	86	213	479	337

* U.S., E.P.A., 1974, p.25.

passenger cars while 7% was sold at retail stores. In 1971 the figures were 45% and 28% respectively (F.E.A., 1975, p.5). Present estimates of car owners changing their own oil go as high as 45% (Rienow, 1975, p.22). Other figures confirm this situation. The backyard tune-up mechanics have grown from 28.3% in 1972 to 33.5% in 1975 (N.P.N., 1976, p.112). It has been estimated that the do-it-yourselfer group could easily generate as high as 100 million gallons of waste oil each year (F.E.A., 1975, p.5).

"A recent report prepared for EPA by Teknekron, Inc. contains information on the ultimate destiny of oil sold over the counter. According to the results of this survey, which was conducted in the Oakland, California area, 43.5 percent of carry out sales are to individuals who add oil to their cars, but do not drain their own oil; 47.5 percent is used for oil changes; and the other 9 percent is sold for both makeup oil and oil changes. Presented without elaboration in the survey is a finding that 16 percent of those who change their own oil changed it at a service station. As to the disposition of oils changed at home, the Teknekron report provides the following: Dump in backyard 33%; Take to service station 15%; Take to public dump 11%; Dump in storm sewer 11%, Dump in garbage can 10%; Dump in empty lot 3%; Other means of disposal 17% (A.P.I., Sept. 1974, p.4).

There are differences of opinion about the advisability of disposal of waste oil on the ground. Kurt Jacobson, an EPA official has been quoted as advising the do-it-yourselfer "your best bet is to bury it in a hole about a foot deep" (Myles,

1975, p.18). In addition, Hot Rod magazine has printed an article explaining how to dig that hole with minimum damage to the lawn (Baker, 1974, p.32). Recent environmental publications have come out strongly against such disposal. For example, "We find the myth that oil spread on the ground is an acceptable disposal method is the most pervasive, most culpatory of practices because it masquerades as proper" (Rienow, 1975, p.22). Another environmentalist states "Waste oil, it has been shown, poses a threat to the environment through groundwater and stream pollution. Small concentrations in surface groundwater can foul drinking water and kill certain marine organisms ... Once a well is poisoned with oil, it's poisoned forever" (Myles, 1975, p.18). Recycling purists feel waste oil should be re-refined to clean lube oil. Burning waste oil is generally considered acceptable disposal, but once it is burned, waste oil is lost forever as a resource. This is why the re-refining industry is trying to convince people that the better use for it would be re-refining instead of burning (Carberry, 1976, p.32). It is not our purpose to discuss this point. In disposing of waste oil by any of the methods we have mentioned, the relevant point is that this oil is a potential resource if it can be collected but the collection of waste oil is probably the weakest link in the entire waste oil or reuse cycle (F.E.A., 1975, p.6).

The largest amount of waste oil is generated by commercial and industrial operations such as service stations, garages, car dealers, auto fleet maintenance shops, industrial firms, railroads, airports and others (F.E.A., 1975, p.6). These

sources of waste oil store the waste oil in holding tanks and when these become filled, a waste oil collector is called to haul the oil away.

The collection industry handles approximately 75% of all waste oil generated. There are between 1000 and 2000 operators using tankwagons with capacities of between 500 and 2000 gallons (F.E.A., 1975, p.7). Until recently, hauls of over 100 miles were usually uneconomical. More recently some collectors are willing to travel 500 miles one way for free waste oil and to pay for it at shorter distances. Because of geographic dispersion in rural areas, these tankwagons cannot operate economically and there is therefore no viable collection system. The collection cost varies between 1 and 5¢ per gallon, and collectors usually sell their waste oil as a feedstock to re-refiners or as a fuel supplement. The collector who is unable to sell the collected oil because of low market demand, disposes of it in the cheapest way possible, e.g. dumping in sewers, in water ways, or at public dumps, without regard for the potential environmental damage (F.E.A., 1975, p.7).

Based on a model study carried out by the State of Maryland, it is anticipated that oil can be collected for between 1¢ to 3¢ per gallon. The system includes intermediate storage plants, and 2800 gallon tank trucks for local collection. A computer program has been developed to design and optimize such a system and could be applied to other regions of the country (U.S. E.P.A., 1974, p.23).

No system has been developed to handle collections for the do-it-yourselfers. The retail stores that sell oil have no provisions for collecting this waste oil. However, some communities are attempting to set up oil receiving stations where the do-it-yourselfers may bring their oil. Mr. Joseph J. Robertson, of the Kansas Department of Health and Environment, has two designs for such collection stations. These designs can be found on pages A-13 and A-14. The Kansas Department of Health and Environment in conjunction with Continental Oil Company is running a pilot program in Topeka to receive the waste oil from the do-it-yourselfers. A five quart plastic container is sold for 49¢ at the Conoco stations in which oil may be carried to the service stations for disposal. The program is receiving radio, T.V. and newspaper advertising support. A copy of the brochure explaining this program can be found on pages A-15 and A-16. It is still too early to evaluate how the program is being received by the community and the do-it-yourselfers.

SECTION IV

RE-REFINING

The converting of waste oil into usable lube stock is done by the re-refining industry. The petroleum re-refining industry, generally using outdated process technology, is 65 years old and has had an uphill struggle in its efforts to exist. The number of re-refiners and the re-refining capacity has decreased from approximately 160 re-refiners producing an estimated 300 million gallons per year of re-refined product in the early 1960's to less than 40 re-refiners, who produced only 90 million gallons of re-refined lube oil in 1972. This figure is about 8% of the total waste oil generated in the U.S. (F.E.A., 1975, p.4).

Re-refining is generally defined as the removal of dirt, water, gasoline, lead and other contaminants from waste oil. Most of the final product is sold as industrial or motor lube oil. According to preliminary studies conducted by the Bureau of Mines, additives should be inserted in this final product in order to restore necessary lubricating capability (U.S. E.P.A., 1974, p.24).

The industry has been declining for technical and economic reasons. The sales of re-refined lubes have been discouraged by Federal labeling and taxation policies. The Federal Trade Commission in 1964 stipulated that re-refined oil products must be labelled "made from previously used oils." This decision, according to re-refiners, is unfair to the re-refined products because the wording implies inferior quality with the

correspondent negative impact on sales (F.E.A., 1975, p.10). The re-refining industry claims that they can turn out a product as good as that from virgin oil. One way to prove that is to subject re-refined oil to some commonly accepted quality control test. However, there are differences of opinion about which test to use. The problem is receiving sympathetic consideration in Washington and the Energy Policy and Conservation Act signed by President Ford in December 1975 directs the National Bureau of Standards to develop test procedures for comparing re-refined oil and virgin oil (Carberry, 1976, p.32). The Federal Trade Commission intends to make no changes in its labelling requirements until this controversy over quality has been resolved (F.E.A., 1975, p.10).

One factor leading to the reduction of re-refiners "was the development of sophisticated additive packages, particularly for motor oils. The existing technology had difficulty in coping with the increased operating requirements at a cost commensurate with available markets for re-refined products, thereby eliminating another group of operators" (Moore, 1976, p.7b). Collection costs have increased and the disposal of acid sludges resulting from some re-refining processes has become more difficult and expensive. Some re-refiners have been forced out of business because they have no place in which to dispose of their acid sludge (Moore, 1976, p.7b).

Collectors who buy waste oil from service stations and other sources sell much of it to fuel oil users who have been able to pay more for it than re-refiners. As a consequence, waste oil prices are rising and re-refiners are resisting the

increase by not operating at full capacity. Many of the present re-refiners are operating at 50% capacity (Carberry, 1976, p.32 & U.S. E.P.A., 1974. p.8. 32. & 62). Another reason for the distressed re-refined oil market is the poor quality oil that was turned out by some re-refiners in the past. This record of poor quality in the past has prevented some potential buyers from entering this market (Carberry, 1976, p.32). The controversy over re-refined lube oil quality continues. Because of the questionable quality of re-refined products, current Federal procurement regulations bar purchase of re-refined oils (F.E.A., 1975, p.10).

Although the re-refining industry has suffered many set backs for all of the before mentioned reasons, nevertheless interest is picking up in re-refined oil and more companies are expected to enter or return to the industry (Davis, 1974, p.62 & F.E.A., 1975, p.10). In this new situation some problems need to be solved. One of them is obtaining enough feedstocks of waste oil. This problem is directly associated with the competition from fuel oil users who are willing to pay more for the waste oil. Another problem to be solved is the improvement of re-refining technology.

The workhorse process of acid/clay treatment is likely to give way to other processes such as solvent extraction, distillation (with hydrotreating), and possibly caustic treatment (Davis, 1974, p.62). According to Norman J. Weinstein of Recon Systems, Inc., the new grass roots re-refining plant should be at least 5-10 million gallons per year in order to be economical. An economic comparison of five basic re-refining

processing schemes is shown in Table 6 (Davis, 1974, p.64). Mr. Weinstein concludes acid/clay treatment is uneconomical in the 5 million gallons per year capacity range. He feels the distilling/hydrotreating process holds promise as an economically attractive process producing no waste products (Davis, 1974, p.62). Most of the industry observers predict that the acid/clay route will eventually be phased out.

There are presently only two re-refiners in Kansas, Coral Re-refining Corporation in Kansas City and Clearwater Trucking Company in Wichita. However several out of state re-refiners are buying waste oil in Kansas. A map showing areas and estimated amounts of collection is included in Table 7 (Goetz & Robertson, 1976).

Coral Re-refining uses the acid-clay process and although it has a production capacity of 5 million gallons per year its present production is only 1.4 million gallons. Presently paying as high as 18¢/gallon for waste oil, this low production is caused primarily by the lack of feed stock at a price they can afford. In fact the railroad, their largest customer for re-refined lube oils, provides its own waste oil and additive package to Coral (O'Blasny & Tierney, 1976).

Coral hopes to change this grim situation in the next year by converting to a new process developed by its owner, Richard O'Blasny. The new process involves dehydrating and fractionating the waste oil to remove water and the light ends, followed by vacuum distillation to produce various grades of oil, then solvent treating with nitrobenzene to remove substantially all undesirable impurities from the oil. The re-refined oil

TABLE 6

SUMMARY OF AVAILABLE PROCESSES FOR WASTE CRANKCASE OIL *

(5 million gal/yr. grass-roots plant)

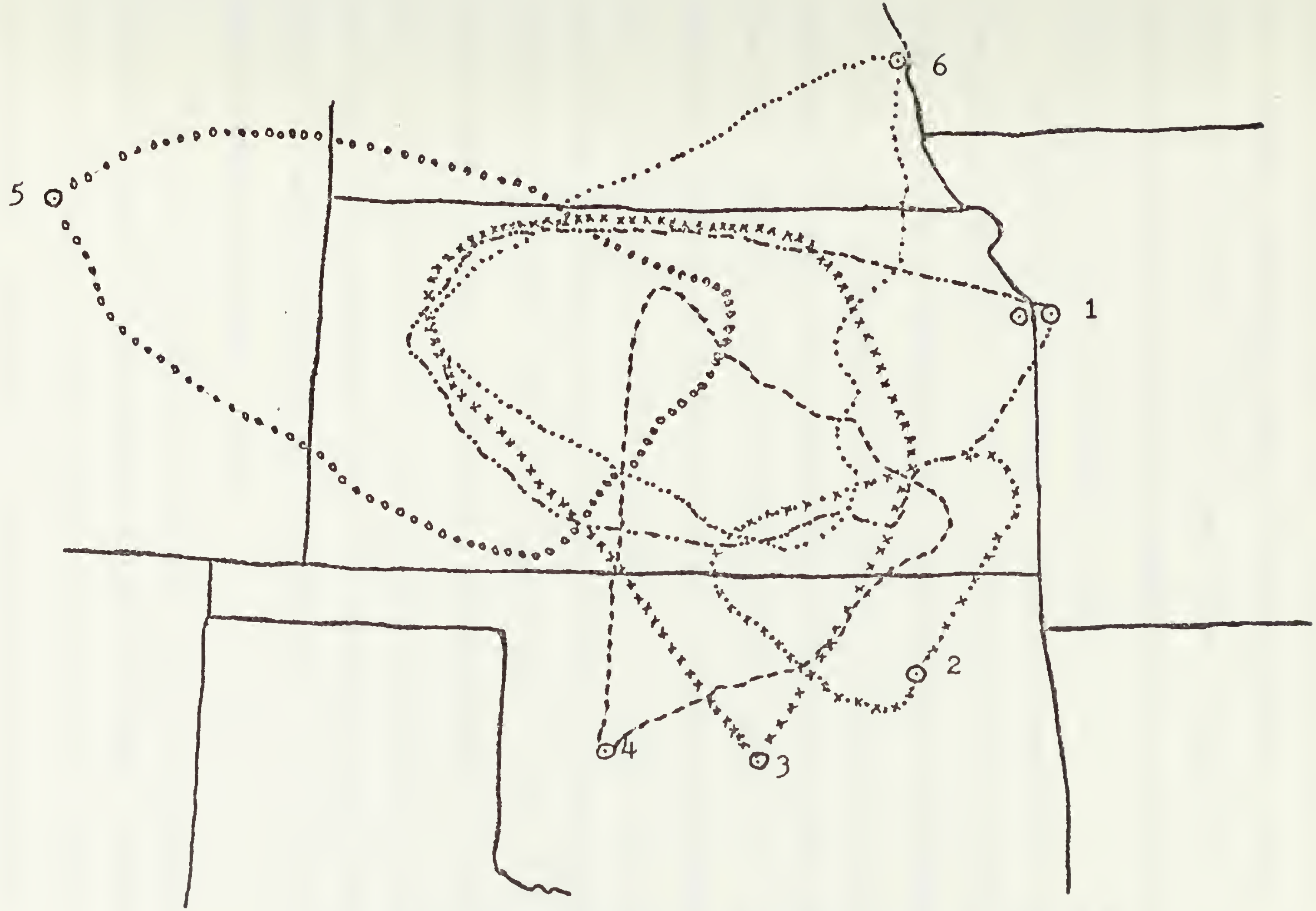
PROCESS	PRIMARY PRODUCT	PRIMARY WASTES & BYPRODUCTS	INVESTMENT**	OPERATING***
Acid/clay	Blending stock	Acid sludge	$1,153,000	21.9¢/gal (lube)
Extraction, acid/clay	Blending stock	Acid sludge, high ash fuel	$1.363,000	18.4¢/gal (lube)
Distillation, clay	Blending stock	Spent clay, high ash fuel	$1.173,000	17.3¢/gal (lube)
Distillation, H_2 treating	Blending stock	High ash fuel	$1,342,000	19.0¢/gal Lube
Distillation	Fuel oil	High ash fuel	$ 930,000	14.6¢/gal (fuel)
Controlled combustion	Steam	Ash concentrate	$ 492,000	80¢/1,000 lb (steam)

* Davis, 1974, p.64.

** Includes: process equip., storage, office & lab facilities, and land & site improvement.

*** Includes: 3¢/gal feed cost and 10%/yr depreciation, but excludes return on investment.

TABLE 7



OUT OF STATE COLLECTION OF WASTE OIL IN KANSAS*

(1) Radium K.C., Ks. > 900,000 gal/yr.
(2) Tulsa Oil Reclaimers, < 72,000 gal/yr.
(3) Double Eagle, Ok. City, Ok. > 250,000 gal/yr.
(4) Panhandle Eastern, Cinton, Ok. < 180,000 gal/yr.
(5) Williams Refining, Denver, Co. < 120,000 gal/yr.
(6) Monarch, East Omaha, Nbr. < 160,000 gal/yr.

*JOE ROBERTSON, KS DEPT. OF HEALTH AND ENVIRONMENT, 1976.

is recovered by steam stripping techniques which also allows collection and reuse of the solvent, thereby materially reducing operating costs. Mr. O'Blasny estimates this process will reduce operating costs by 15¢ to 18¢ per gallon. Hopefully this will put him in a much more competitive situation with other waste oil users and improve the availability of feed stock (O'Blasny & Tierney, 1976).

In Wichita, Hap Harpster, owner of Clearwater Trucking Company, is building a pilot re-refinery with a production capacity of a 2.6 million gallons using the clay-distillation process. If this plant is successful he hopes to get financial backing to build a 6 to 8 million gallons per year plant. He has been building his collection network for over a year and presently has an inventory of over a million gallons of waste oil. His primary source is truck fleet users. Once in operation he will be able to pay up to 16¢/gallon for waste oil He has a commitment from a custom blender to buy all his re-refined lube oil for use as blending stock at $1.60 per gallon. In fact this same custom blender has invested in the re-refinery to insure an alternative supply of blending stock as a hedge against possible interruption or shortage of traditional virgin lube sources (Harpster, 1976).

With two re-refiners in Kansas there is potential for a dramatic growth in re-refined lube oil volume. If the nationally projected growth in this industry comes about, Kansas will certainly be a part of it. Obviously this would have a major impact on the availability and cost of waste oil used as a fuel.

SECTION V

WASTE OIL LEGISLATION

Federal and various state proposed waste oil laws are broad in the sense of the many provisions included, but at the same time A.P.I. calls them "narrow in scope" (A.P.I., 1976, p.2) because they only focus attention on the means to encourage re-refining.

On the federal level there are several bills dealing with waste oil. President Ford's Energy Policy and Conservation Act (in section 383) directed the National Bureau of Standards to develop specifications and testing procedures to facilitate comparison of re-refined oil with virgin oil intended for the same purpose. Many subsequent provisions in other legislation are dependent on these tests and specifications, e.g. the elimination of "previously used" labeling requirement for re-refined oils and the Defense Supply Agency's ban on procurement of re-refined lube oils.

The reason these new testing procedures are so important to re-refiners is that the currently used engine sequence test costs \$10,000 to \$30,000 each time it is run. This prohibitive cost works against the re-refiner who must run it on each batch of oil he produces due to the lack of consistency of his feed stock. As a result, he doesn't use the test at all. In contrast the virgin lube refiner only runs the test every 2-5 years when his crude feed stock changes (Shuldiner, 1976, p.63).

Other Federal legislation includes House Bill 6860, the Energy Conservation and Conversion Act of 1975 which would repeal the excise tax on re-refined oil that is blended with virgin oil. Presently virgin lube oil enjoys what most people consider an unfair tax advantage over re-refined oil in the off highway markets (F.E.A., 1975, pp. 9 & 10).

The most important bill is the National Oil Recycling Act, H.R. 6011 of April 15, 1975. It is presently being held in committee awaiting the new specifications from the Bureau of Standards. This bill also calls for repeal of the excise tax, repeal of the F.T.C. labeling requirements (new labels would only specify grade), and repeal of governmental procurement restrictions. In addition, it would require oil to be sold in resealable containers, the licensing of collectors, records kept by any firm using more than 100 gallons/year of lube oil, and research grants in re-refining technology. This bill would put the re-refining industry back on its feet. The authors feel that Frost and Sullivan's prediction of a re-refining boom is to some extent based on the anticipated passage of this or a similar law.

Several states have proposed waste oil legislation. An Illinois proposal is similar to House Bill 6011 but has an additional requirement for all end user outlets of lube oil to install waste oil storage facilities (Bahr and Dunwoody, 1974, p.7). At this time Kansas does not have any proposed waste oil legislation (Goetz, 1976).

The policy of the F.E.A. "is to try to remove some of the federal impediments to the re-refining industry ... The

F.E.A. wants to step up efforts to recover collectable waste oil. What to do with it once it is collected is not so clear." Alternatives other than re-refining are acceptable and economically viable (Shuldiner, 1976, p.63). This stance is in line with the A.P.I., whose position is that the choice among uses for waste oil "should be based on economics rather than on government regulation or subsidy" (A.P.I., 1976, p.10). Of course the A.P.I. lobbying efforts need to be considered when making judgment on what form and how quickly final legislation will be enacted.

In summary, legislation has been proposed which could have an adverse effect on the amount of waste oil available to K.U. as fuel. Its exact effect is difficult to judge at this time. The authors feel the next 3-5 years are critical in determining the direction of future laws and their impact on waste oil as a supplemental fuel for the University of Kansas.

SECTION VI

PROJECTIONS OF WASTE OIL VOLUMES

In Kansas both the Kansas Energy Office and the Department of Health and Environment are concerned with the volume of waste oil generated and its ultimate disposal within the state. They want to insure that waste oil, as a potential resource is put to the best possible use, and as a potential pollutant does not harm the environment. The Kansas Energy Office has made the following estimates of automotive lube oils for the state (Goltz & Weaver, 1976):

12.0	million gallons/year	virgin lube used
4.5	"	consumed in use
2.7	"	waste burned as fuel
2.25	"	waste used by railroads
.9	"	waste used as road oil
.4	"	waste re-refined
1.35	"	waste unaccounted for

The Kansas Department of Health and Environment has recently completed a preliminary study of waste oil which resulted in the waste oil flow diagram shown as Figure 1. These figures are considered very conservative by the H & E Department (Robertson, April 1976, p.1). A further breakdown of their estimate is given in Table 8 (Robertson, April 1976, p.2).

In addition to these estimates, Mr. Robertson conducted a survey of 400 automobile owners in February 1976 with these results:

(1) the average amount of lube oil purchased was 4.8 gal/yr/car

(2) 78% changed their oil 4x/yr

(3) 10% changed their oil 5x/yr

(4) 5% changed their oil 2x/yr

(5) those who changed their own oil disposed of it as follows:

backyard	28%	storm sewer	8%
service station	20%	empty lot	4%
public landfill	12%	other	10%
garbage can	18%		

(6) 84% indicated a willingness to participate in a recycling program.

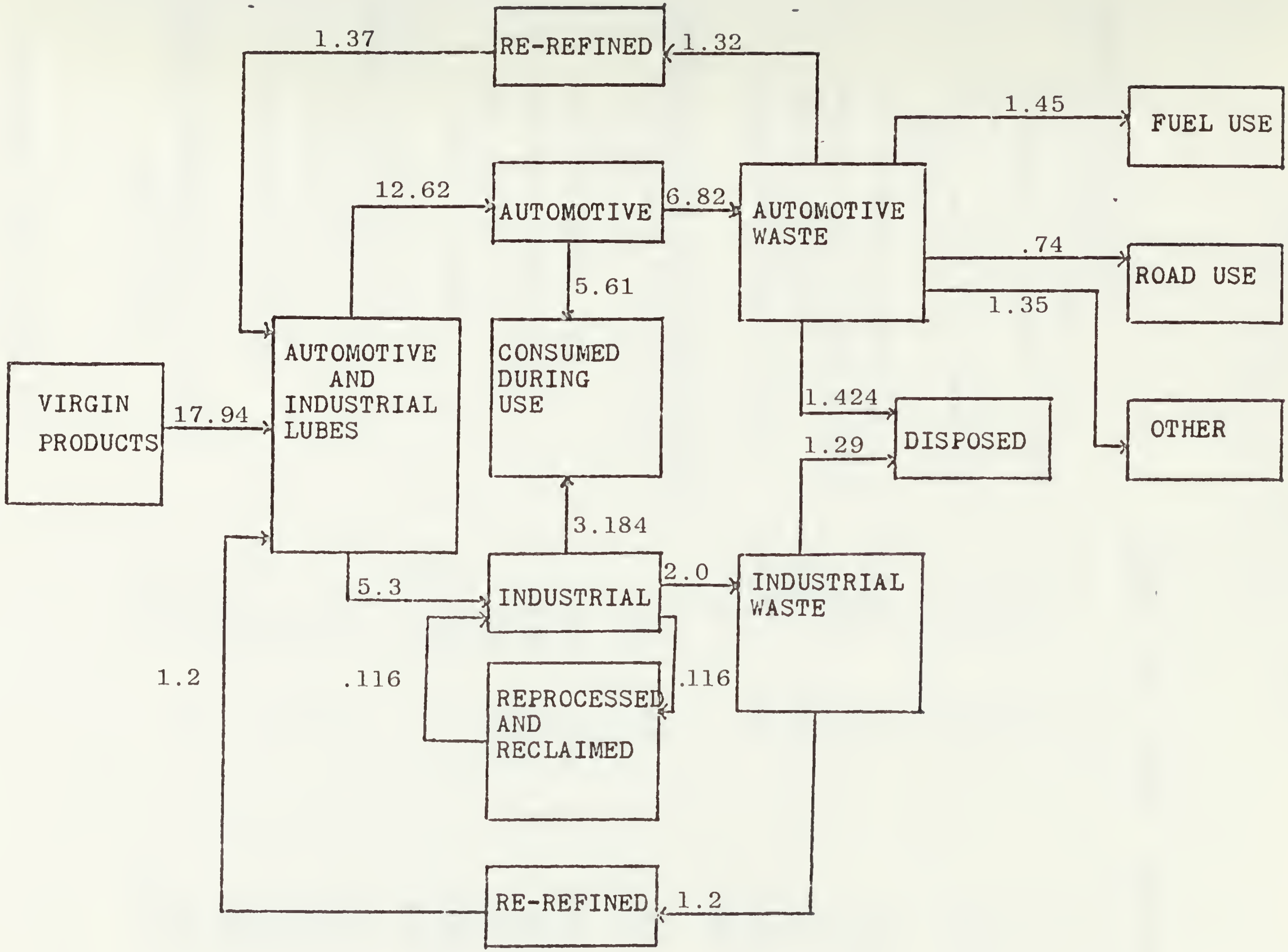
The survey was conducted in various retail stores that sell lube oil (262 contacts) and by phone (138 contacts). Because of the nature of the survey no commercial fleet users (taxis, auto rentals, etc.) were contacted. This is an important point in explaining the difference between the survey result of 4.8 gal/yr/car, the Kansas average of 13.8 gal/yr motor vehicle and the U.S. average of 9.5 gal/yr motor vehicle. In fact it should be noted that dividing the H & E Department estimate of 12.25 million gallons of automotive lube oil sales by the 1974 Kansas motor vehicle registrations yields a figure of 6.86 gal/yr/motor vehicle.

In the formulation of waste oil projections the authors used the following as their statistical data base:

(1) U.S. and Kansas total, automotive, and industrial lube oil demand 1960-1973 as reported in the biennial U.S. Bureau of the Census Current Industrial Reports.

(2) U.S., Kansas, and Douglas, Franklin and Jefferson county

FIGURE 1



KANSAS WASTE OIL FLOWS(1974),MILLION GALLONS

FIG. 1

TABLE 8

KANSAS WASTE OIL GENERATION (1974) *

(Millions of Gallons)

	SALES	W.O. FACTOR	WASTE OIL
AUTOMOTIVE LUBE OILS			
Service Stations	2.7	.63	1.701
Garages, auto supply stores	1.245	.63	.784
New car dealers	.995	.90	.896
Retail sales for commercial engines	.968	.63	.610
Auto fleet & other uses	1.365	.50	.683
Factory fills (auto & farm)	.825	.90	.743
Discount stores	2.0	.22	.44
Commercial engine fleets	2.15	.50	1.075
	12.25		6.932
INDUSTRIAL and AVIATION LUBE OILS			
Hydraulic & circulating system oils	.325	.42	.137
Metal working oils	.150	.42	.063
Railroad engine oils	1.850	.53	.981
Gas engine oils	.620	.90	.558
Aviation & other	1.370	.50	.685
	4.32		2.424
OTHER INDUSTRIAL OILS			
Process oils	.310	.10	.031
Electrical oils	.570	.90	.513
Refrigeration oils	.100	.50	.050
	.98		.594
LUBES PURCHASED BY U.S. GOVT.	.37	.50	.185
GRAND TOTALS	17.91		10.135

* Robertson, April 1976, p.2.

populations 1960-1975 as reported in the Kansas Statistical Abstract.

(3) U.S., Kansas, and Douglas, Franklin and Jefferson county motor vehicle registrations 1960-1975 as reported in the U.S. and Kansas statistical abstracts.

(4) U.S. projected total and automotive lube demand 1975-1985 as predicted in National Petroleum News Factbook 1976.

(5) U.S. and Kansas projected populations 1980-2000 using U.S. Bureau of the Census series "E" projections as reported in the Kansas Statistical Abstract.

This data is shown in Figures 2, 3, & 4 and in tabular form on pages A-1 to A-4.

In Figure 2 (and on page A-2) the Kansas projected total lube demand is based on the linear regression of 1960-1973. The authors have little confidence in this projection due to its high growth rate in relation to the rate projected for the U.S. It is presented only for comparative purposes.

In Figure 3 (and on page A-3) the three county (Douglas + Franklin + Jefferson) projected population is based on the linear regression of 1970-1975 projected to 1980. The growth rate of the U.S. was used to project 1980-2000. The authors feel the growth pattern of these three counties will more closely approximate that of the U.S. rather than Kansas. It should be noted that using the U.S. growth rate to project from 1975-2000 the projection of 1980-2000 is identical to the one shown, i.e., the only difference between the two methods is in the years 1976-1979. The University of Kansas, Lawrence campus, fall enrollment is shown only as an item of general interest.

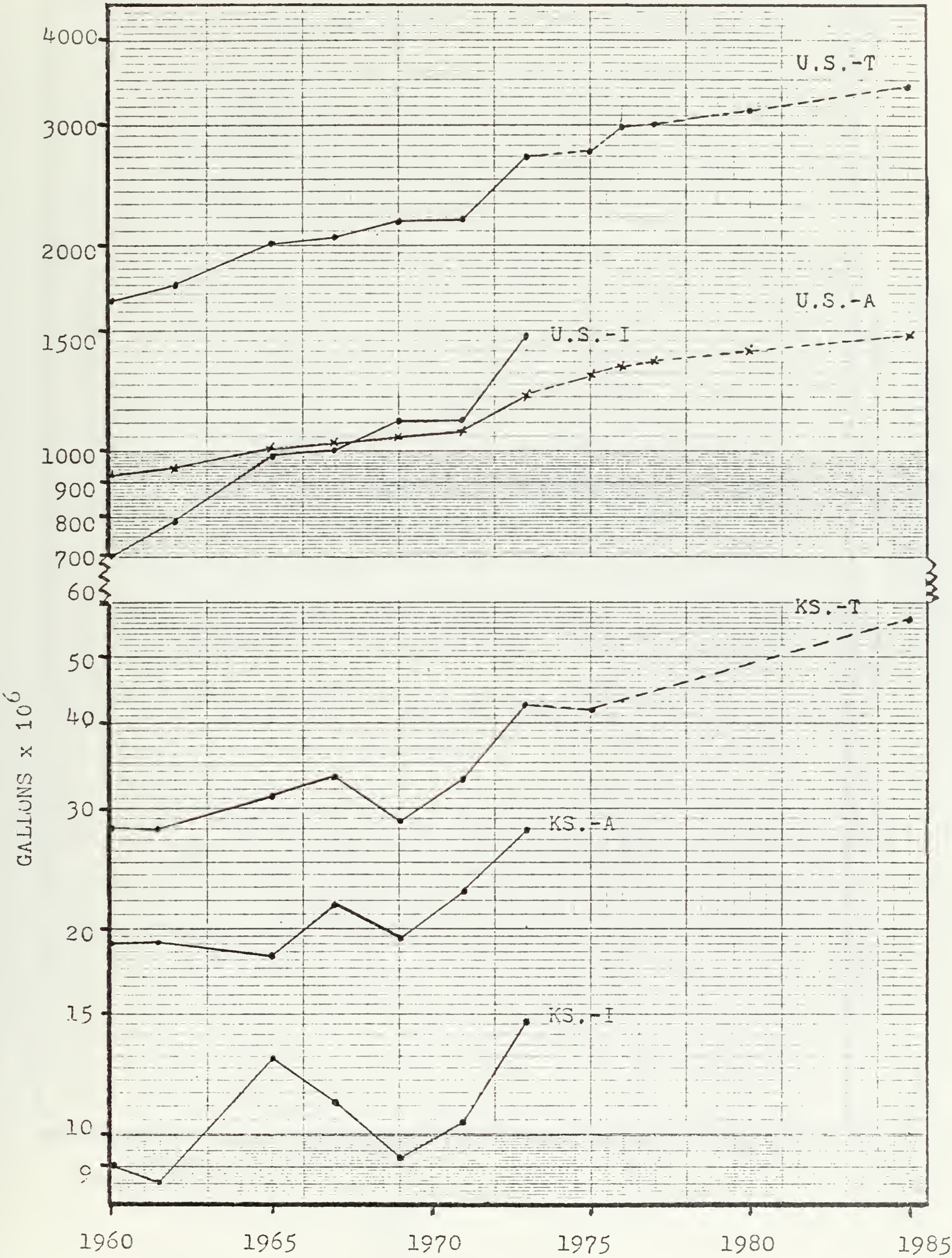
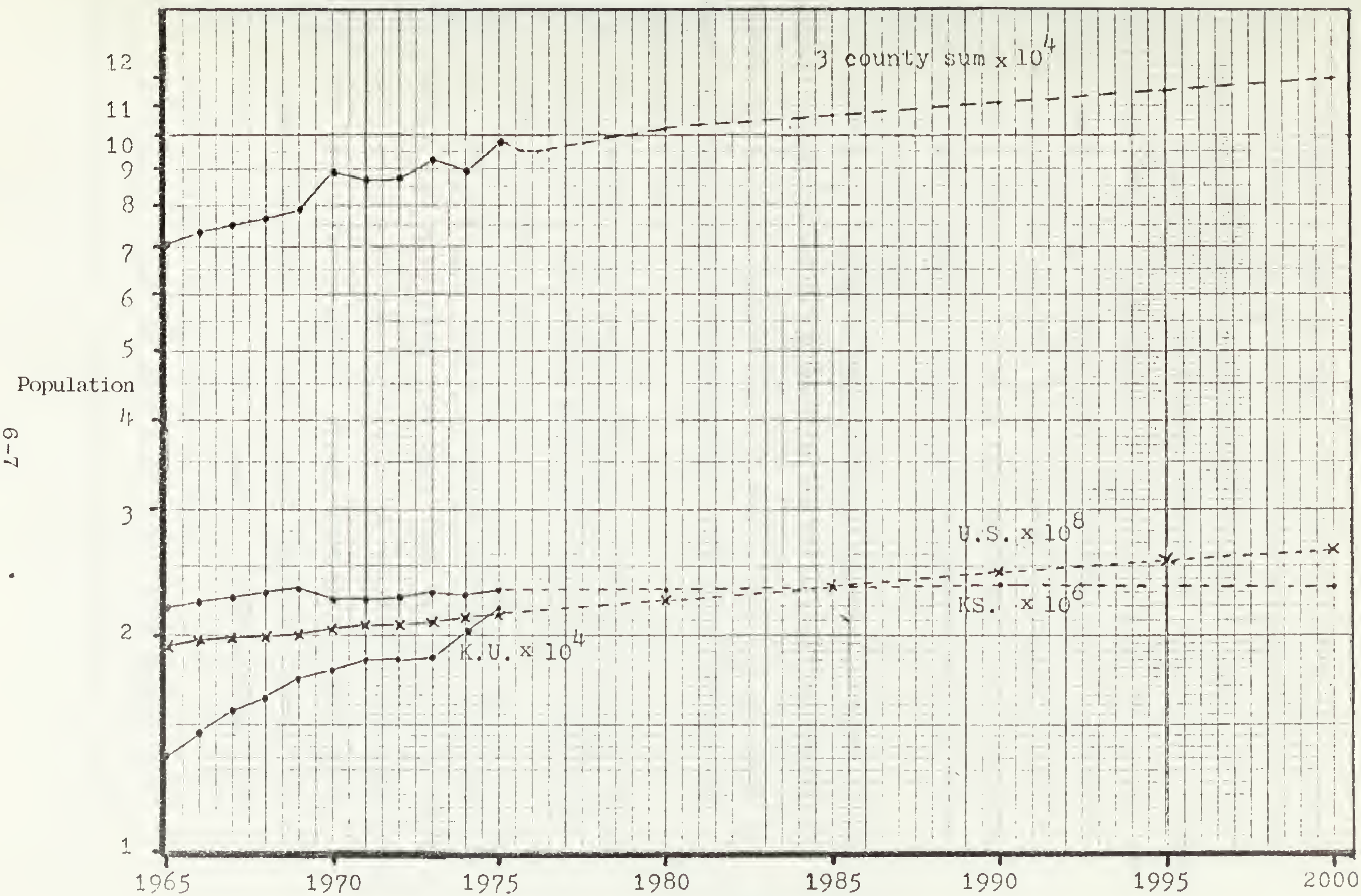


Figure 2 LUBE OIL DEMAND

U.S. and KS.- TOTAL-T, AUTOMOTIVE-A, INDUSTRIAL-I.



POPULATION

Figure 3

U.S., KS. and 3 County sum.

In Figure 4 (and on page A-4) the motor vehicle registration projections are based on the projected populations (shown in Figure 3) and the projected population per motor vehicle (shown in Figure 5). After considering the alternatives (linear regression, etc.), the authors selected this method as the best; first, because the authors have a high degree of confidence for the projected populations, and second because they felt it was more logical to predict the saturation level of population per motor vehicle rather than the growth rate of motor vehicle registrations.

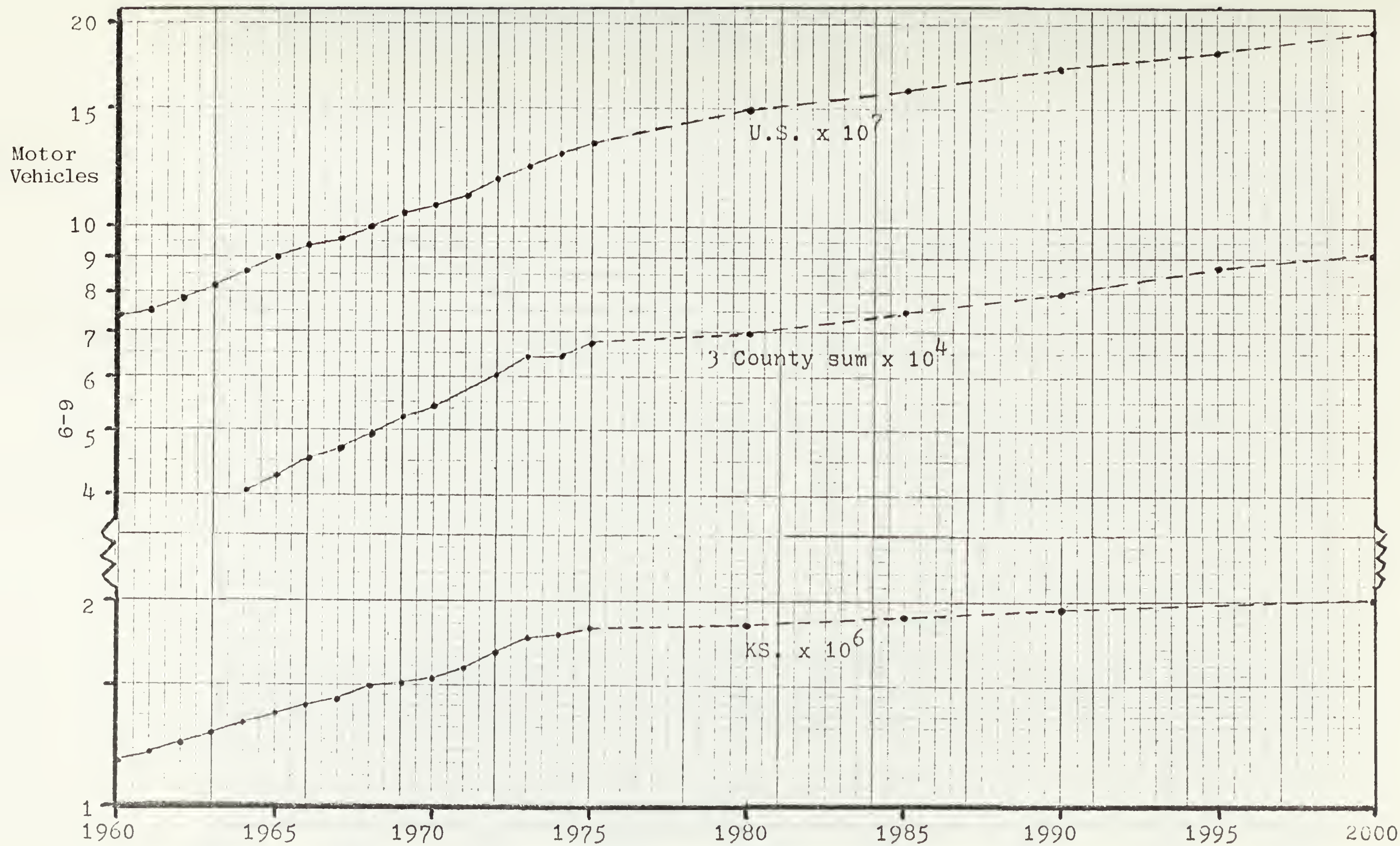
In Figure 5 (and on page A-5) the authors present their major assumptions for the prediction of automotive waste oils. These projections (population per motor vehicle) are used to make the motor vehicle projections. The logic behind the assumptions is:

(1) For Kansas, the rate of decline of population per motor vehicle for the period 1973-1975 continue to the year 2000 to reach a low of 1.15.

(2) For the U.S. the rate of decline 1974-1975 will continue until 1.5 is reached. At that time the rate of decline will reduce so that 1.35 will be reached in the year 2000.

(3) For the three counties, after considering their past trends relative to the U.S. and Kansas and the projected figures for the U.S. and Kansas, it was assumed they would reach 1.28 by the year 2000.

In Figure 6 (and on page A-6) total lube demand per capita is displayed. The graph is self-explanatory as the



6-9

Figure 4

MOTOR VEHICLE REGISTRATION

U.S.,KS. and 3 County sum.

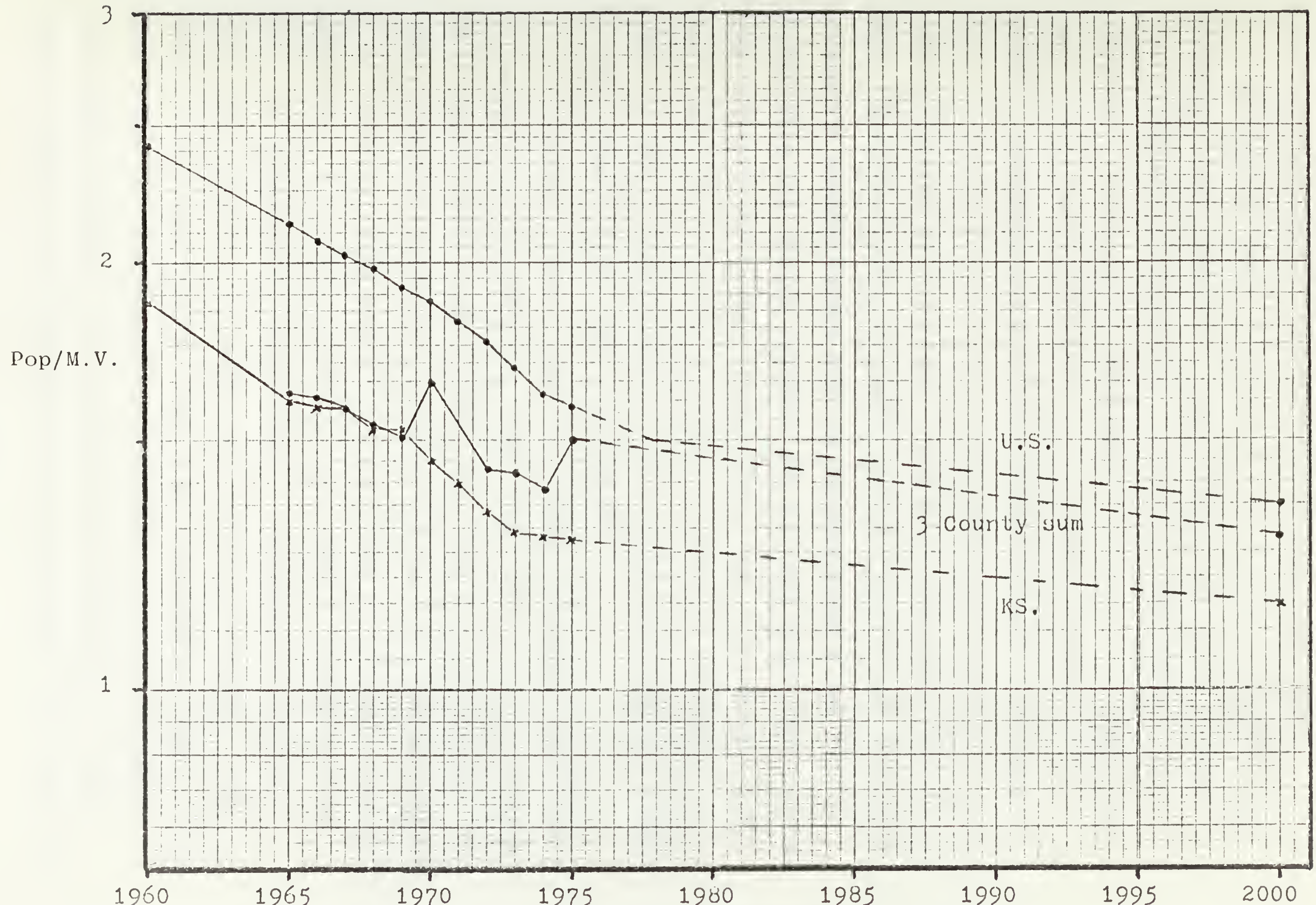


Figure 5

POPULATION/ MOTOR VEHICLE REGISTRATION
U.S., KS. and 3 County sum.

only figures used are those of the original data base.

In Figure 7 (and on page A-7) the Kansas projection of automotive lube demand per motor vehicle is based on the linear regression of data for the period 1960-1973. The projection in the period 1975-1985 for the U.S. is based on the N.P.N projected automotive lube demand divided by the authors' projected motor vehicle registrations (see figure 4). The U.S. projection for the period 1985-2000 assumes that the rate of decline of the linear regression 1960-1973 resumes in 1985. This assumption is based on the thought that the major automotive manufacturers will be recommending a one year or 10,000 mile oil change interval for all new model cars by that time (Linnard and Holman, 1976, p.2). The authors also feel that long drain interval synthetic automotive lubricants will begin to take a larger share of the automotive lube oil market by 1985 (Dunne, April 1976, pp. 90-99).

In Figure 8 (and on page A-8) total waste oil projections in the period 1975-2000 are shown. The method used in making these projections is as follows: For the U.S. and Kansas, the 1971 estimated total waste oil for the U.S. and Kansas (Chansky et al, 1974, pp. A-1 and A-3) was divided by the 1971 respective populations to produce waste oil per capita figures of 4.84 and 7.72 gallons/year respectively. The mean of these two values was used as the factor for the three counties. The proper factor was then multiplied by the projected populations (see Figure 3) to produce the projected waste oil volumes. Also shown in Figure 8 is the waste oil projection to 1985 based on 50% of the projected total lube demand (see Figure 2).

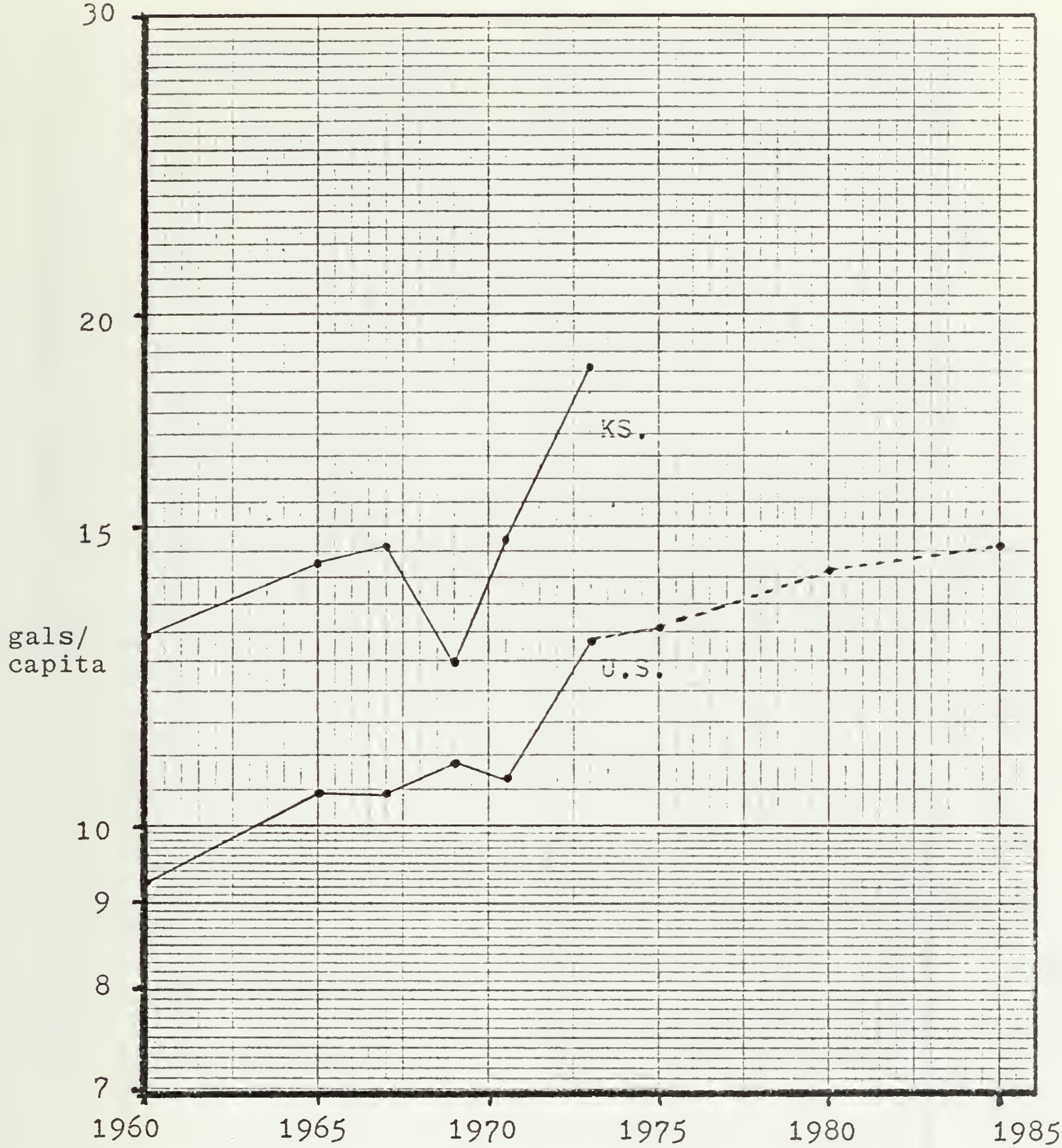
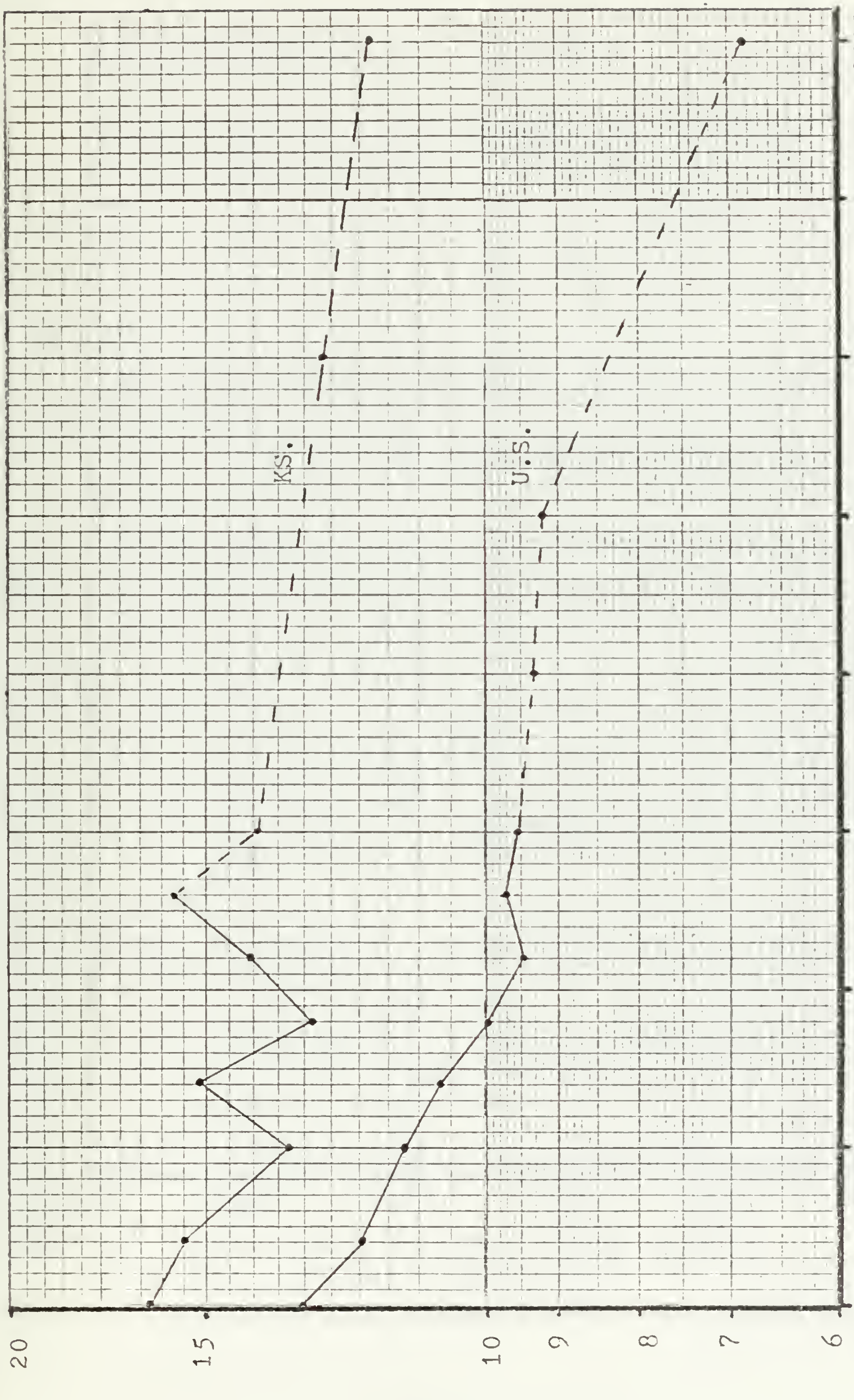


Figure 6 TOTAL LUBE DEMAND/CAPITA, GALLONS/CAPITA.
U.S. and KS.



AUTOMOTIVE LUBE DEMAND/ MOTOR VEHICLE REGISTRATION

U.S. and KS.

Figure 7

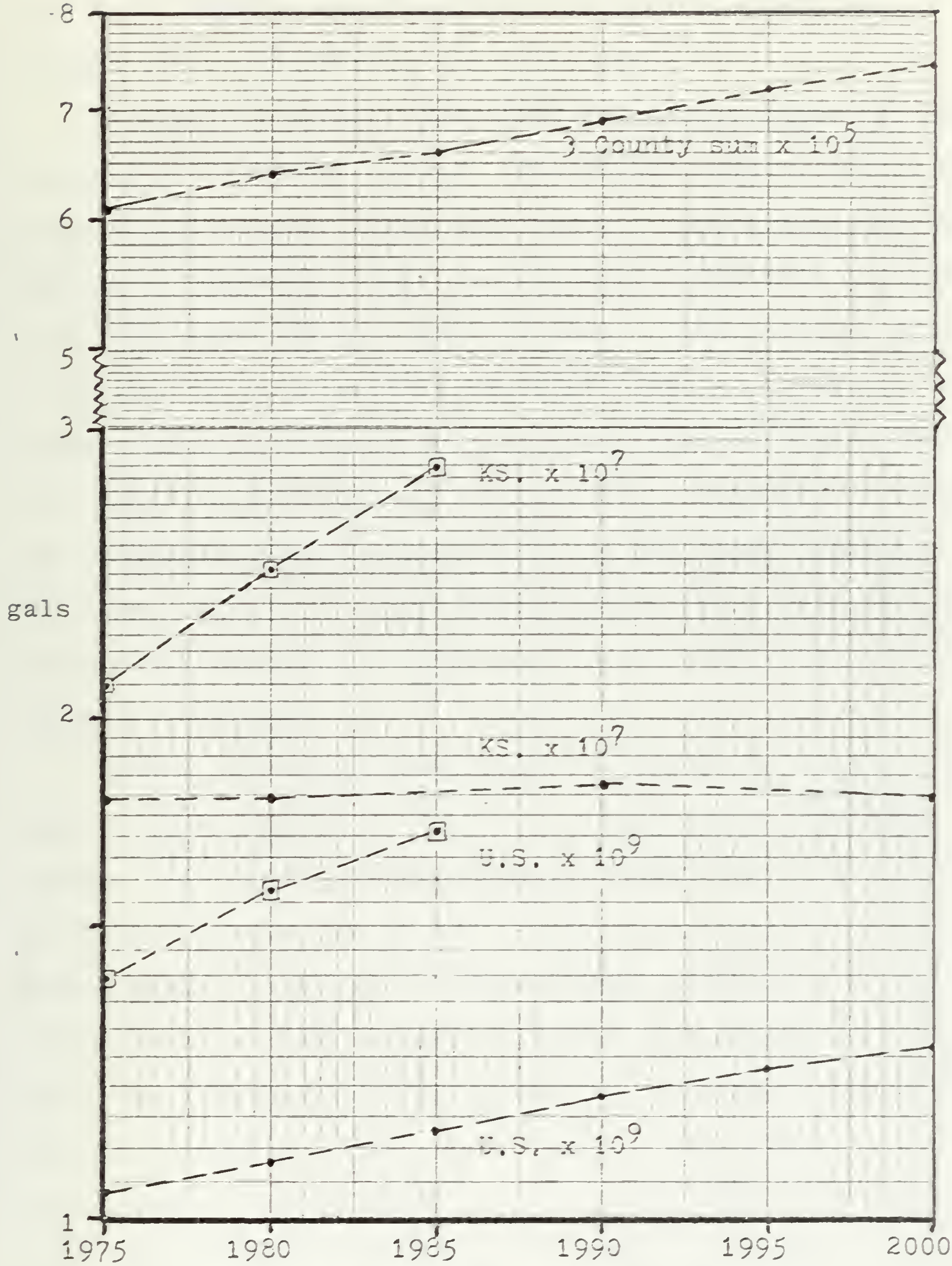


Figure 8 TOTAL WASTE OIL PROJECTIONS, GALLONS
U.S., KS. and 3 County sum.
⊡ PROJECTION ASSUMING W.O. = 50% TOTAL LUBE DEMAND

This is a commonly used method of estimating waste oil volumes and is shown here for that reason.

In Figure 9 (and on page A-9) automotive waste oil projections 1975-2000 are shown. The method used in making these projections is as follows: For the U.S. and Kansas the 1971 respective automotive lube demands were divided by the respective 1971 motor vehicle registrations. These numbers were multiplied by an automotive waste oil factor of 63% to produce automotive waste oil per motor vehicle figures of 5.97 and 8.91 gallons/year respectively. The mean of these two values was used as the factor for the three counties. The proper factor was then multiplied by the projected motor vehicle registrations (see Figure 4) to produce the projected waste oil volumes.

Figure 10 (and on page A-10) is similar to Figure 9 in that it shows automotive waste oil projections 1975-2000. However, in this case the <u>projected</u> automotive lube demand per motor vehicle (see Figure 7) was multiplied by an automotive waste oil factor of 63% and then multiplied by the projected motor vehicle registrations (see Figure 4). For the three counties the U.S. projected automotive lube demand per motor vehicle figures were used for the computations. The purpose of this figure is to show the effect of increased crankcase oil drain intervals on automotive waste oil volumes.

Figures 11, 12, and 13 are a consolidation of the last three figures (waste oil projections) by regions (U.S., Kansas and the three counties respectively). In Figure 11 the U.S. waste oil projection for 1985 made by Frost and Sullivan is

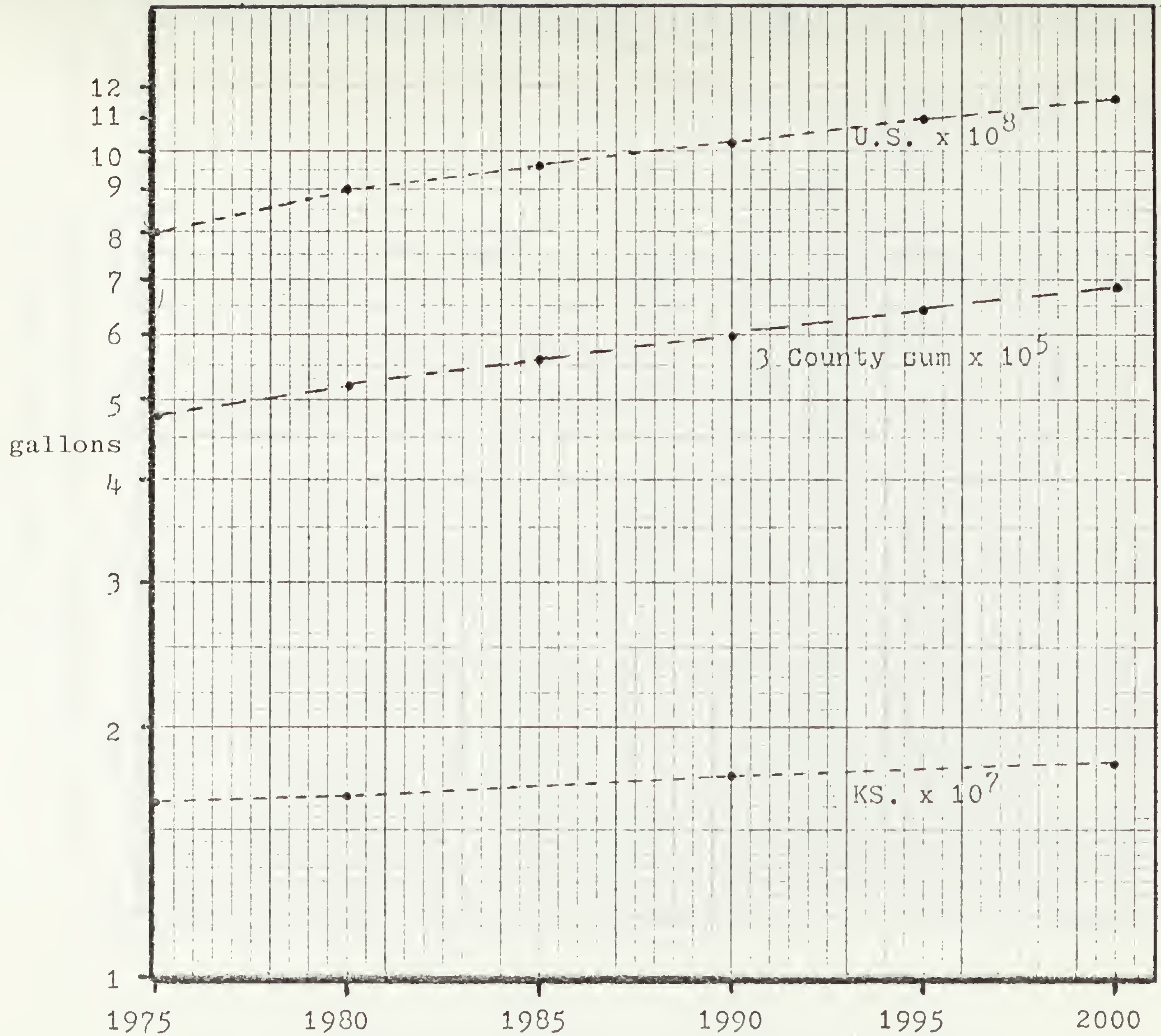


Figure 9 AUTOMOTIVE WASTE OIL PROJECTION, GALLONS
U.S., KS. and 3 County sum.

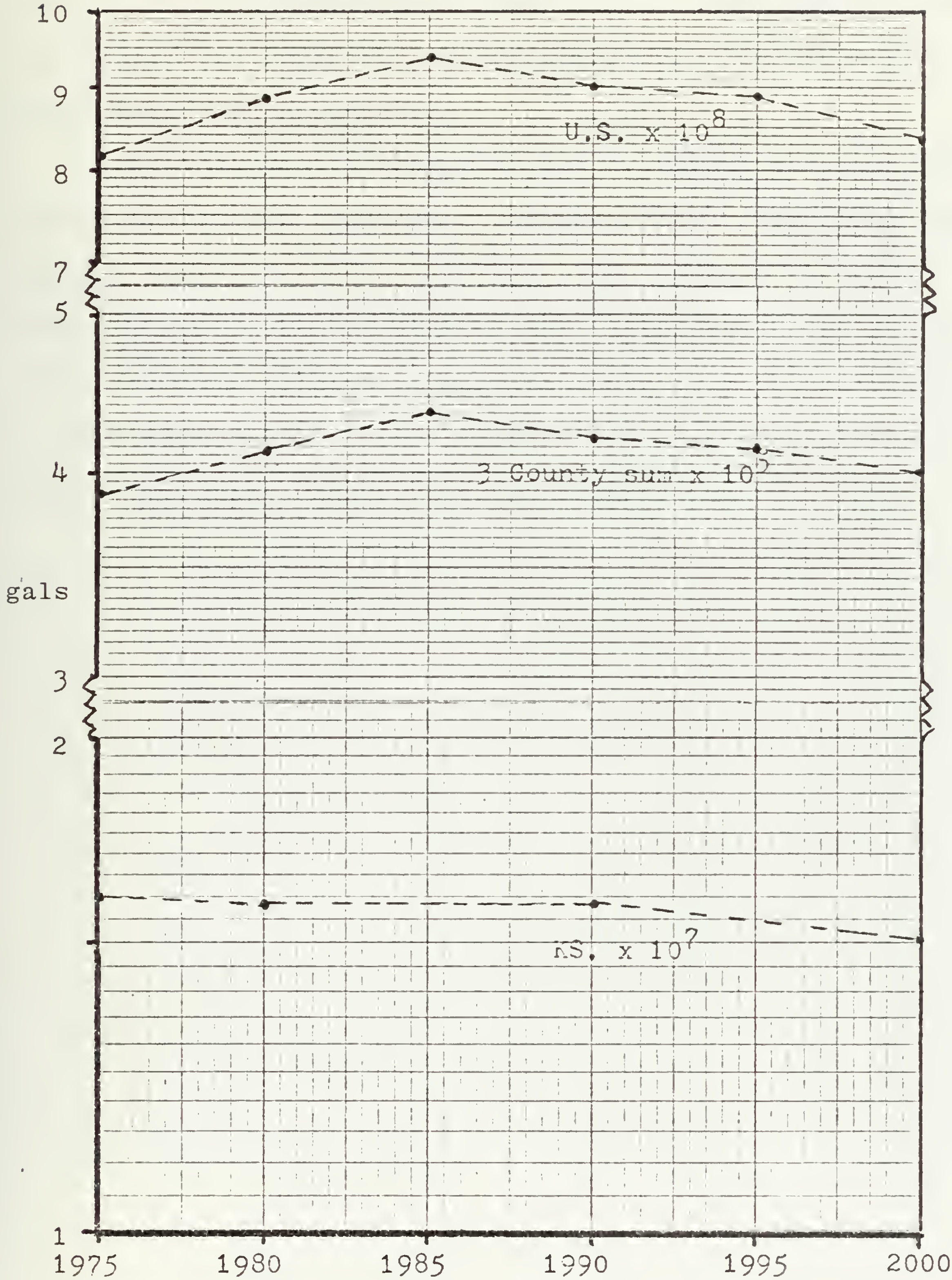


Figure 10 AUTOMOTIVE WASTE OIL PROJECTIONS, GALLONS.
U.S., KS. and 3 County sum.

shown. It is interesting to note that it falls exactly between the projection using 50% of lube demand and the projection using waste oil per capita.

Figure 14 is a correlation of U.S. demand for industrial lube oils with the seasonally adjusted Total Industrial Production Index (T.I.P.I.) forecast (Lee, 1976, p.26 & 27). Lube oil sales in 1973 is considered abnormally high and in 1975 abnormally low (reduction of inventory). This figure is only shown as an item of general interest since there is such a high correlation for this forecast.

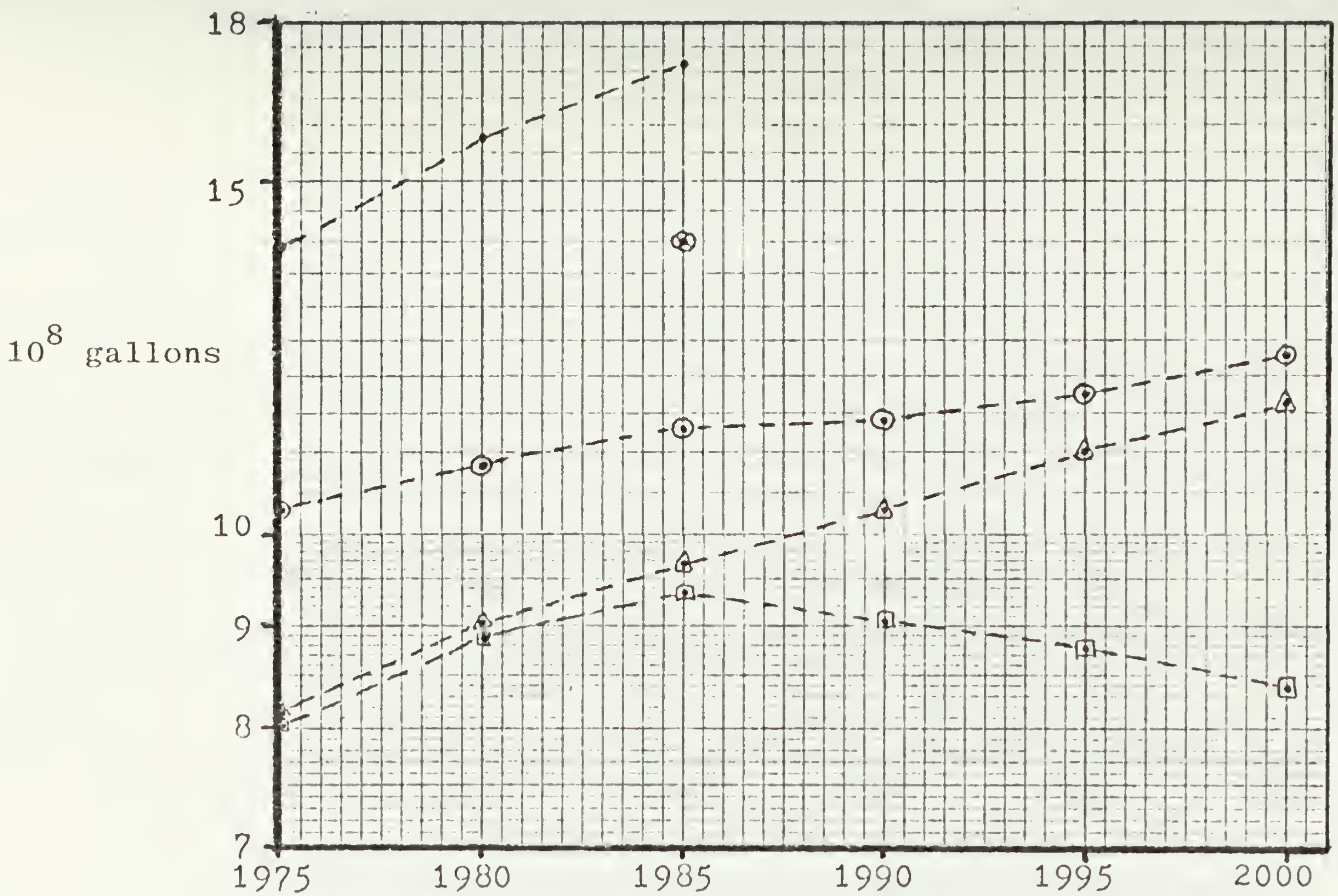


Figure 11 U.S. WASTE OIL PROJECTION, 10^8 GALLONS.

· TOTAL WASTE OIL BASED ON 1/2 PROJECTED LUBE DEMAND.

⊗ FROST AND SULLIVAN, TOTAL WASTE OIL PROJECTION FOR 1985.

⊙ TOTAL WASTE OIL PROJECTION BASED ON WASTE OIL PER CAPITA AND PROJECTED POPULATION.

△ AUTOMOTIVE WASTE OIL PROJECTION BASED ON AUTOMOTIVE WASTE OIL PER MOTOR VEHICLE AND PROJECTED MOTOR VEHICLE REGISTRATION.

⊡ AUTOMOTIVE WASTE OIL PROJECTION BASED ON PROJECTED AUTOMOTIVE WASTE OIL PER MOTOR VEHICLE AND PROJECTED MOTOR VEHICLE REGISTRATION.

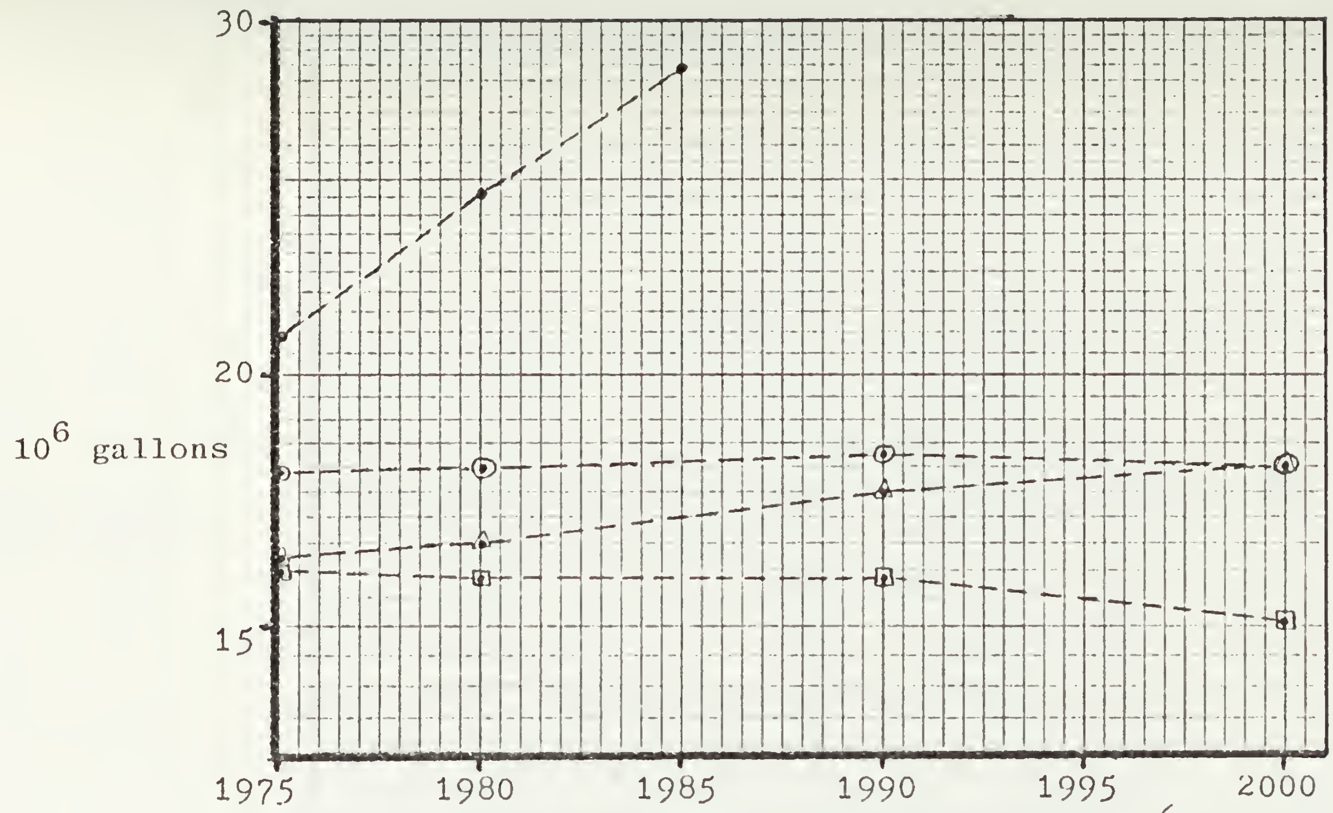


Figure 12 KANSAS, WASTE OIL PROJECTIONS, 10^6 GALLONS.

· TOTAL WASTE OIL BASED ON 1/2 PROJECTED LUBE DEMAND.

⊙ TOTAL WASTE OIL PROJECTION BASED ON WASTE OIL PER CAPITA AND PROJECTED POPULATION.

△ AUTOMOTIVE WASTE OIL PROJECTION BASED ON AUTOMOTIVE WASTE OIL PER MOTOR VEHICLE AND PROJECTED MOTOR VEHICLE REGISTRATION.

⊡ AUTOMOTIVE WASTE OIL PROJECTION BASED ON PROJECTED WASTE OIL PER MOTOR VEHICLE AND PROJECTED MOTOR VEHICLE REGISTRATION.

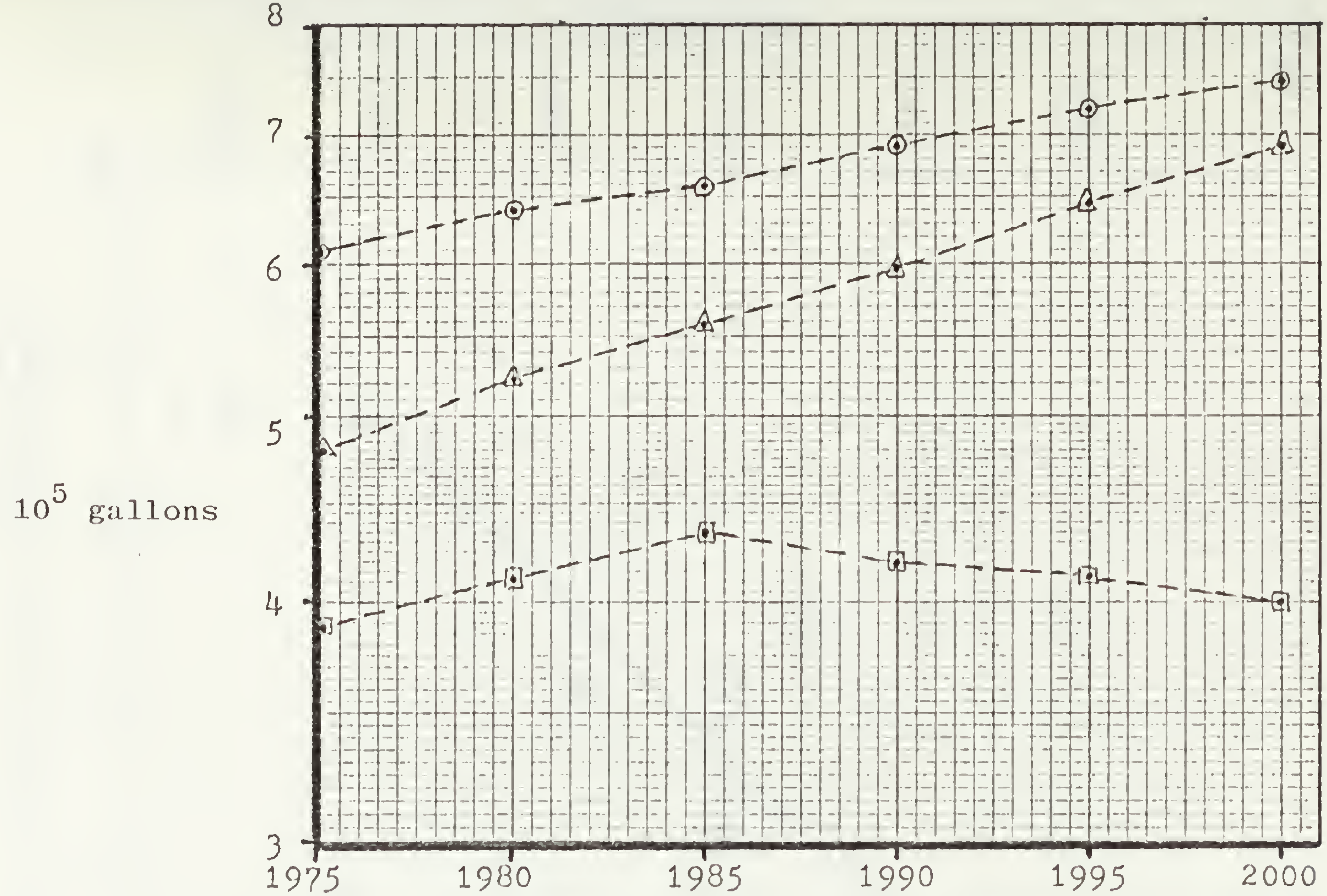


Figure 13 3 COUNTY SUM, WASTE OIL PROJECTION, 10^5 GALLONS

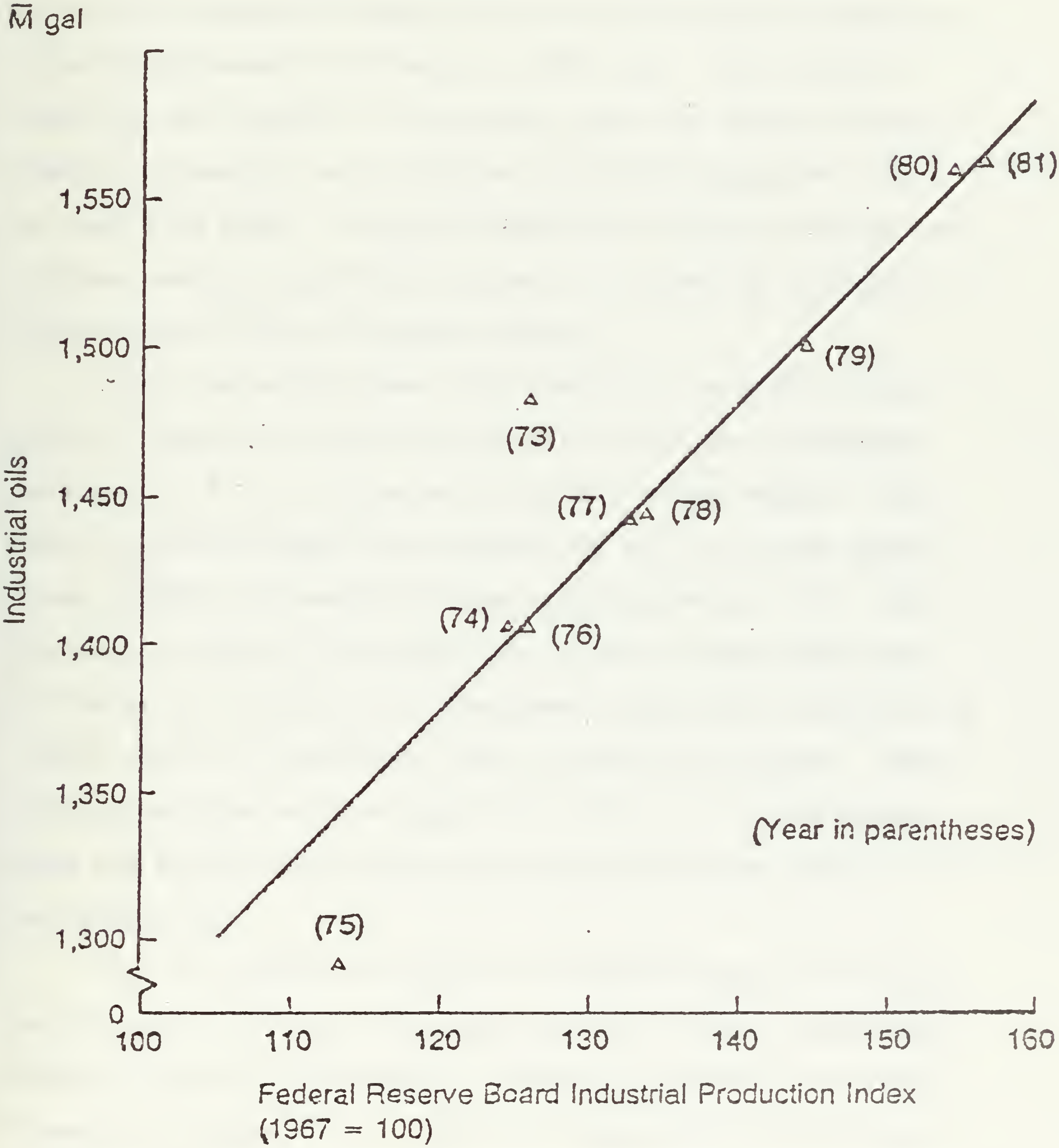
⊙ TOTAL WASTE OIL PROJECTION BASED ON WASTE OIL PER CAPITA AND PROJECTED POPULATION.

△ AUTOMOTIVE WASTE OIL PROJECTION BASED ON AUTOMOTIVE WASTE OIL PER MOTOR VEHICLE AND PROJECTED MOTOR VEHICLE REGISTRATION.

⊡ AUTOMOTIVE WASTE OIL PROJECTION BASED ON PROJECTED AUTOMOTIVE WASTE OIL PER MOTOR VEHICLE AND PROJECTED MOTOR VEHICLE REGISTRATION.

FIGURE 14

Domestic Demand for Industrial Oils as a Linear Function of Industrial Production Index (TIPI)*
Projected to 1981



*Lee, 1976, p.26.

SECTION VII

WASTE OIL AS AN ENERGY ALTERNATIVE FOR THE UNIVERSITY OF KANSAS

Preliminary studies indicate that approximately 300,000 to 400,000 gallons of waste oil per year would be needed as a fuel supplement (W.P. Smith, 1976, p.2). The authors' analysis (see Figure 13) indicates that the three counties, Douglas, Franklin, and Jefferson generate enough waste oil to meet this need. In this chapter the authors discuss the options available and the economics involved in choosing a supplemental fuel for winter peaking.

First the established local waste oil collectors and several examples of local waste oil prices are discussed followed by E.P.A. estimated waste oil price ranges. Then fuel oil price trends are examined as well as price comparisons ($/BTU) for several fuels including waste oil. Next, the use of waste oil storage facilities to take advantage of its price volatility is discussed along with estimates of "free" waste oil available from a recycling program. Then the authors discuss the impact of a waste oil re-refining boom and finally draw their conclusions and make their recommendations.

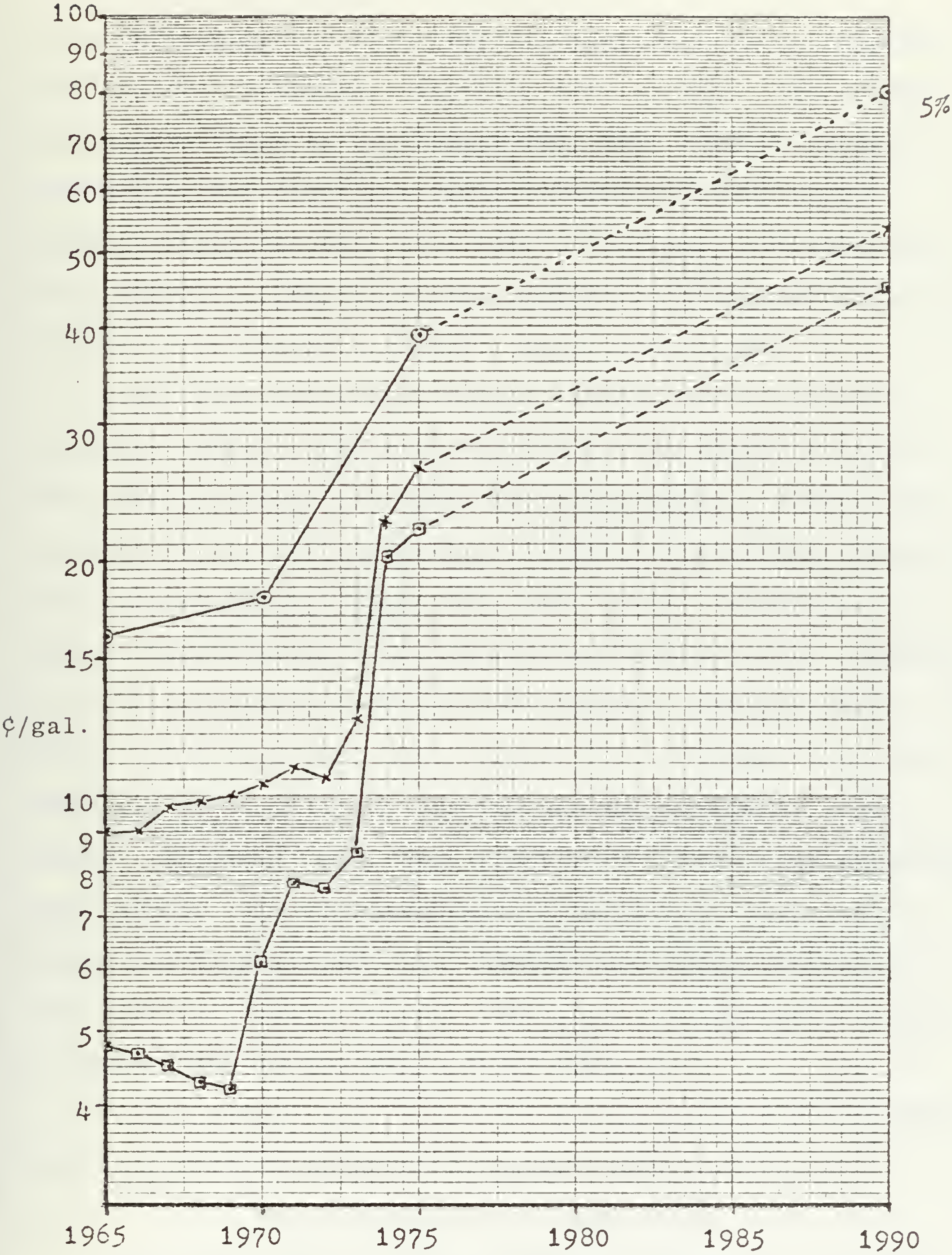
If K.U. selects the option of buying waste oil from an established collector, two companies are likely candidates, Capital City Oil Collection in Topeka and Radium Petroleum Company in Kansas City. These two companies are the major collectors in the three county area. Capital City Collection

is a relatively new company (three years old) and handles an annual volume of about 300,000 gallons. They have two 2000 gallon trucks and tank storage of 25,000 gallons (Frank Smith, 1976). By contrast Radium is much larger with 20 trucks and 500,000 gallon tank storage. From the greater Kansas City area alone, Radium collects about 960,000 gallons/year (Deffenbaugh, 1976). Again it is obvious the necessary volume for K.U. is available. The question now becomes "How much of this waste oil will be economically available to the University?"

When considering the economics of the situation, the price of waste oil is of primary concern. In section V, some prices were given which Kansas re-refiners are willing to pay for waste oil (6-18¢/gal.). It is assumed that other customers will have to meet this price. As an example of the price competition K.U. faces, recently Double Eagle Re-refining of Oklahoma City bid 10.5¢/gal for the waste oil contract at Fort Riley (Frank Smith, 1976). This is a fairly high price when one considers the additional transporation costs to Oklahoma. In Wichita a collector pays service stations 0-3¢/gal for their waste oil and then sells it for 6-9¢/gal (Holder, 1975, p.51). This "collection or transportation" cost of 6¢/gal appears to be in line with E.P.A.'s estimated transportation cost of 4.5¢/gal which does not include any allowance for profit (Chansky, 1974, p.144).

In the same study the E.P.A. estimated the market price (defined as processing cost + transportation cost + profit) of waste oil sold as a fuel product to range between 15.8 - 24.5¢/gal for low level (e.g. settling) treatment and to

FIGURE 15



FUEL OIL PRICE TRENDS, ¢/GALLON
⊙ RETAIL PRICE HOME HEATING FUEL
× WHOLE SALE PRICE LIGHT FUEL
⊡ WHOLE SALE PRICE HEAVY FUEL

range between 18.1 - 27.9¢/gal for high level (e.g. vacuum distillation) treatment (Chansky, 1974, p.144). The prices the authors found in the Kansas City area confirm the E.P.A. estimates. Two other published estimates of the market price of waste oil sold as a fuel are 10¢/gal less than fuel oil (Carberry, 1976, p.32) and 90-95% of the market price of residual fuel oil (U.S. E.P.A., April 1974, p.63).

Since fuel oil is an obvious alternative to waste oil, its price trend is shown in Figure 15. The 1965-1975 wholesale price of light and heavy fuel oils (N.P.N., 1976, p.83) is shown as well as the average retail price of home heating fuel oil (Changing Times, July 1976, p.4). Projections to 1990 are shown based on a conservative growth of 5%. Based on all the research conducted, the authors estimate that Kansas collectors sell their waste oil at 0-3¢/gal above the wholesale price of heavy fuel oil during periods of high demand. At other times they build their inventories and lower their prices. As with most waste commodities, waste oil prices are highly volatile. However the energy crisis of 1973 with the ensuing higher fuel costs has certainly served to improve the market position of waste oil.

The following table compares the prices of various energy sources including waste oil (Chansky, 1974, p.145).

FUEL SELLING PRICE COMPARISONS

Fuel Type	gal/10^6Btu	¢/gal	¢/10^6/Btu
Untreated waste oil	7.19	9.0	64.71
Low treated waste oil	6.90	20.12	138.83

Fuel Type	gal/10^6Btu	¢/gal	¢/10^6/Btu
High treated waste oil	6.67	22.99	153.34
Residual oil	6.58	20.0	131.60
Distillate oil	7.30	26.25	191.63
Coal (> 3% sulfur)	76.92/lb	.51/lb	39.23

Even though the prices are and will continue to change it is obvious that waste oil compares very favorably with other fuel oil prices. However, it should be noted that coal prices are substantially lower than those for waste oil. This is important since coal is another alternative supplemental fuel for K.U. A similar analysis should also be made for wood.

Some of the assumptions made in making the "Fuel Selling Price Comparisons" above are shown in the following table (Chansky, 1974, p. F-1).

Fuel Type	Btu/gal	lb/gal	Btu/lb
Untreated waste oil	139,000	7.5	18,533
Low treated waste oil	145,000	7.3	19,863
High treated waste oil	150,000	7.5	20,000
#6 residual oil	152,000	8.0	19,000
#2 distillate oil	137,000	7.2	19,028
Coal (>3% sulfur)	NA	NA	13,000

The water content of waste oil is of major concern when estimating Btu's/gallon. Waste oil typically contains 5-30% water by volume. Coral Re-refining estimates water removal using a one step dehydration flash would increase the cost of waste oil by 5¢/gallon (O'Blasny, 1976).

A possible solution to this price problem is to have a large enough storage capacity to enable K.U. to buy the oil during low price periods for use during peak demand. Since the supplementary fuel would only be needed four months of the year this could be a viable alternative. The amount of waste oil desired as a possible backup in the event of a garbage collectors strike is another thing that needs to be considered when deciding on waste oil storage facilities. Further cost studies would be needed in order to make a decision.

There is some amount of waste oil that would be available to K.U. at no cost. For example the Buildings and Grounds garage drains approximately 1400 gallons of waste oil yearly. If K.U. sponsors a recycling program for the do-it-yourselfers the authors estimate 40,000 to 50,000 gallons/year could be realized. This estimate is based on the following:

(1) 37000 motor vehicles in Douglas County

(2) 35% of these change their own oil

(3) 4.5 gallons waste oil/year/motor vehicle is generated (20 quarts/year X 90%)

(4) 75% of the generated waste oil would be recycled.

The Federal Energy Administration is developing a kit to assist communities in setting up and promoting waste oil recycling programs. When the kit becomes available, about December 1976, one will be sent to K.U. (Webb, 1976). The results of the Conoco recycling pilot program in Topeka should be monitored to better estimate the value of such a program to K.U.

One of the major problems in collecting waste oil is the geographic dispersion of lube oil users. This problem is especially acute in rural areas. For example, there are about 3,200 farms in the three county area (Kansas Statistical Abstract, 1976, p.238). The average farmer in this area uses about 60-80 gallons/year of lube oil (Dieker and Polk, 1976). This is a potential of about 179,200 gallons of waste oil (70 gal x 80% x 3200) of which very little is presently collected.

Commercial and industrial sources are more economical for collection due to the larger volumes of waste oil per collection point that they generate. Possible industrial sources are listed on page A-20. The authors estimate 60,000 gallons/year of lube oil is sold to industrial accounts in Douglas County alone (Dieker and Polk, 1976).

A boom in the re-refining industry could have a major impact on the availability of waste oil as a fuel. Frost and Sullivan predict by 1985 60% of all waste oil will be re-refined (up from the present 9.3%). They say this growth will largely be at the expense of waste oil as a fuel (Carberry, 1976, p.32). The authors feel three things are important in producing this boom: (1) a breakthrough in re-refining technology (very possible, see section IV), (2) financial backing to implement the new technology (questionable due to the past history of re-refining and the competition for capital), and (3) favorable legislation. Legislation is such a key factor it was examined separately in section V.

The authors conclude that the use of large volumes of waste oil as a supplemental fuel for winter peaking is possible (i.e. there is sufficient waste oil available) but is economically very risky due to the volatility and general rising nature of waste oil prices. The waste oil alternative would also involve additional costs in terms of liquid fuel storage and handling facilities.

When compared with other petroleum based fuels the waste oil alternative is the best choice. However, the authors feel that before the optimal choice can be made for K.U., the non-petroleum fuel alternatives such as wood and coal need to be explored further. It was noted earlier that the cost of coal was less than waste oil ($/BTU). It would seem that wood and coal offer an additional advantage over liquid fuels in that their storage and handling characteristics are similar to the primary energy source, solid waste.

The authors recommend that the new steam plant should have the capability of burning waste oil with the solid waste. Therefore K.U. would be able to take advantage of the waste oil available at little or no cost. Unfortunately the amount of "free" waste oil is not seen to have any major impact on the winter peaking requirements and therefore other sources of cheap energy (e.g. additional trash, wood, or coal) need to be sought.

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APPENDICES

U.S. LUBE OIL DEMAND*

(Thousands of Gallons)

YEAR	TOTAL	AUTOMOTIVE	INDUSTRIAL
1960	1,655,954	924,645	705,734
1962	1,766,094	945,493	798,444
1965	2,028,963	1,015,809	997,791
1967	2,058,953	1,031,784	1,014,105
1969	2,184,031	1,050,935	1,113,202
1971	2,193,755	1,071,065	1,114,256
1973	2,706,029	1,214,352	1,482,321
1975	2,777,500	1,292,500	
1976	2,981,000	1,342,000	
1977	3,019,500	1,353,000	
1980	3,168,000	1,408,000	
1985	3,432,000	1,485,000	

* National Petroleum News, Fact Book, 1976, p. 75.

KANSAS LUBE OIL DEMAND*

(Thousands of Gallons)

YEAR	TOTAL	AUTOMOTIVE	INDUSTRIAL
1960	28,163	19,001	9,008
1962	28,039	19,151	8,575
1965	31,378	18,265	12,981
1967	33,301	21,891	11,275
1969	28,943	19,500	9,316
1971	33,117	22,611	10,410
1973	42,939	28,018	14,783
1975	41,800 **		
1980	49,000 **		
1985	51,700 **		

* U.S. Bureau of Census, Current Industrial Reports

** Linear regression of 1960 - 1973 projected to 1985

POPULATION *

(000)

YEAR	DOUGLAS	FRANKLIN	JEFFERSON	3 CTY SUM		KANSAS	U.S.
1960	43.72	19.55	11.25	74.52		2,179	179,323
1965	37.92	21.08	11.21	70.22		2,198	193,815
1966	40.40	21.41	11.52	73.33		2,220	196,858
1967	42.62	21.25	11.57	75.44		2,281	197,863
1968	43.59	21.45	12.07	77.10		2,303	199,861
1969	45.31	21.40	12.28	79.00		2,321	201,921
1970	57.93	20.01	11.95	89.88		2,249	204,766
1971	54.08	20.17	12.15	86.40		2,249	206,212
1972	54.78	20.30	12.41	87.49		2,278	208,837
1973	59.38	20.68	12.63	92.69		2,302	209,851
1974	55.6	20.8	12.8	89.2		2,299	211,390
1975	63.8	20.6	12.8	97.2		2,314	213,137
U.S. BUREAU OF CENSUS SERIES "E" PROJECTIONS							
1980				102	**	2,324	222,769
1985				106	**		234,068
1990				111	**	2,364	245,075
1995				115	**		254,495
2000				121	**	2,331	262,494

* Kansas Statistical Abstracts 1976

** Population Assuming Growth Rate of U.S.

MOTOR VEHICLE REGISTRATIONS *

(000)

YEAR	DOUGLAS	FRANKLIN	JEFFERSON	3 CTY SUM	KANSAS	U.S.**
1960					1,163	73,869
1961					1,190	75,847
1962					1,234	79,023
1963					1,282	82,748
1964	22.15	11.56	7.01	40.72	1,328	86,297
1965	23.58	11.97	7.30	42.84	1,369	90,358
1966	25.16	12.51	7.63	45.30	1.405	94,193
1967	26.33	12.95	7.82	47.09	1.441	96,931
1968	28.10	13.49	8.16	49.75	1,501	100,885
1969	29.59	14.00	8.63	52.22	1,515	105,097
1970	30.89	14.27	8.99	54.15	1,548	108,400
1971					1,599	112,900
1972	34.64	15.81	10.14	60.59	1,692	118,600
1973	36.81	16.44	11.15	64.40	1,778	125,421
1974	36.72	16.32	11.42	64.46	1,785	129,938
1975	36.96	16.22	11.53	64.71	1,820	133,727
Projections based on $\frac{\text{Projected Population}}{\text{Projected Population/Motor Vehicle}}$						
1980				70.35	1,859	151,029
1985				75.18		161,426
1990				80.29	1,970	172,883
1995				86.79		184,416
2000				92.97	2,027	194,440

* <u>Kansas Statistical Abstract</u>, 1976

** <u>U.S. Statistical Abstracts</u>, 1975

POPULATION / MOTOR VEHICLE

YEAR	3 COUNTIES	KANSAS	UNITED STATES
1960		1.87	2.42
1965	1.63	1.60	2.14
1966	1.61	1.58	2.08
1967	1.58	1.58	2.04
1968	1.54	1.53	1.98
1969	1.51	1.53	1.92
1970	1.65	1.45	1.88
1971		1.40	1.82
1972	1.44	1.34	1.76
1973	1.43	1.29	1.68
1974	1.38	1.28	1.62
1975	1.50	1.27	1.59
Projections Made by Authors:			
1980	1.45	1.25	1.48
1985	1.41	1.23	1.45
1990	1.37	1.20	1.42
1995	1.33	1.18	1.38
2000	1.28	1.15	1.35

TOTAL LUBE DEMAND/CAPITA

(GALLONS/YEAR)

YEAR	KANSAS	UNITED STATES
1960	12.92	9.23
1965	14.27	10.46
1967	14.59	10.40
1969	12.47	10.81
1971	14.72	10.63
1973	18.65	12.89
1975		13.03*
1980		14.22*
1985		14.66*

* N.P.N. Projected Lube Demand ÷ Projected Population

AUTOMOTIVE LUBE DEMAND/MOTOR VEHICLE

(GALLONS/YEAR)

YEAR	KANSAS	UNITED STATES
1960	16.33	12.51
1962	15.52	11.96
1965	13.34	11.24
1967	15.19	10.64
1969	12.87	9.99
1971	14.14	9.48
1973	15.75	9.75
1975	13.80	9.66
1980	13.50	9.32
1985	13.10	9.20
1990	12.70	8.33
1995	12.30	7.55
2000	11.80	6.85

Kansas projections based on linear regression of 1960-1973.

U.S. projections 1975-1985 based on <u>NPN</u> projected automotive lube demand divided by projected motor vehicle registrations.

U.S. projections 1990-2000 based on the U.S. 1960-1973 rate of decrease resuming in 1985.

PROJECTED TOTAL WASTE OIL

(GALLONS)

YEAR	3 COUNTY SUM $X\ 10^3$	KANSAS $X\ 10^6$	UNITED STATES $X\ 10^6$
1975	610	17.86	1,031
1980	641	17.94	1,078
1985	659		1,132
1990	691	18.25	1,186
1995	722		1,231
2000	747	17.99	1,270

U.S. projections based on:

$$\frac{\text{1971 E.P.A Total U.S. W.O. Estimate}}{\text{1971 U.S. population}} \times \text{Projected U.S. Population}$$

Kansas projections based on:

$$\frac{\text{1971 E.P.A. Total Ks. W.O. Estimate}}{\text{1971 Kansas population}} \times \text{Projected Kansas Population}$$

3 County projections based on:

$$\frac{\text{1971 EPA US+KS W.O./Capita Estimate}}{2} \times \text{Projected 3 Cty. Population}$$

PROJECTED AUTOMOTIVE WASTE OIL

(GALLONS)

YEAR	3 COUNTY SUM	KANSAS	UNITED STATES
	$X\ 10^3$	$X\ 10^6$	$X\ 10^6$
1975	481	16.2	800
1980	523	16.5	902
1985	559		964
1990	597	17.5	1,030
1995	646		1.101
2000	692	18.0	1.161

U.S. Projections based on

$$\frac{\text{1971 U.S. Auto Lube Demand}}{\text{1971 U.S. Motor Vehicles}} \times 63\% \times \begin{array}{l}\text{Projected U.S.}\\ \text{Motor Vehicles}\end{array}$$

Kansas Projections based on

$$\frac{\text{1971 Kansas Auto Lube Demand}}{\text{1971 Kansas Motor Vehicles}} \times 63\% \times \begin{array}{l}\text{Projected Kansas}\\ \text{Motor Vehicles}\end{array}$$

3 County Projection based on

$$\frac{\begin{array}{c}\text{1971 U.S. \& Kansas Auto}\\ \text{Lube Demand/M.V.}\end{array}}{2} \times 63\% \times \begin{array}{l}\text{Projected 3 Cty.}\\ \text{Motor Vehicles}\end{array}$$

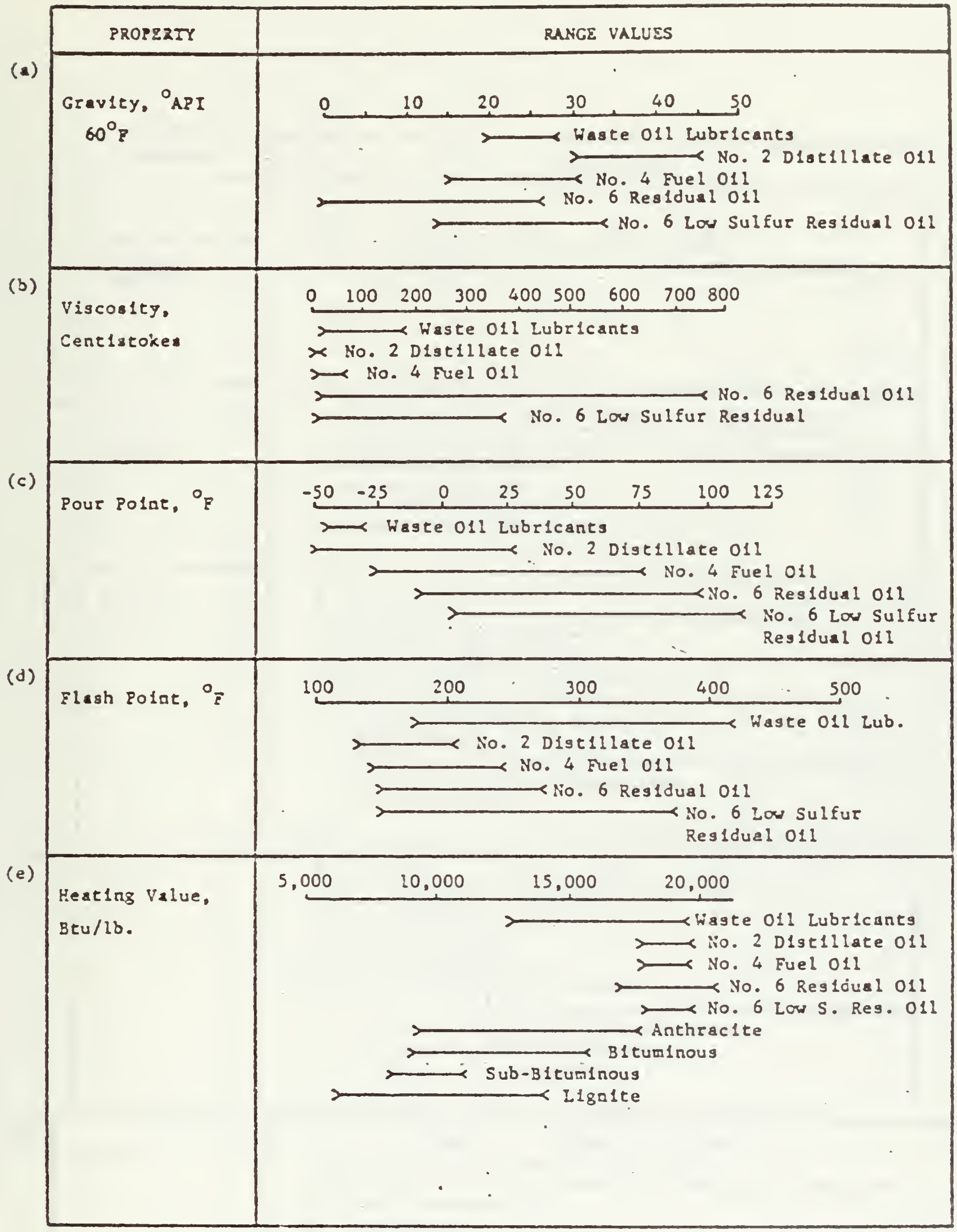
PROJECTED AUTOMOTIVE WASTE OIL

(GALLONS)

YEAR	3 COUNTY SUM	KANSAS	UNITED STATES
	X 10^3	X 10^6	X 10^6
1975	389	16.0	845
1980	412	15.8	887
1985	436		936
1990	420	15.8	904
1995	413		877
2000	401	15.1	839

Based on

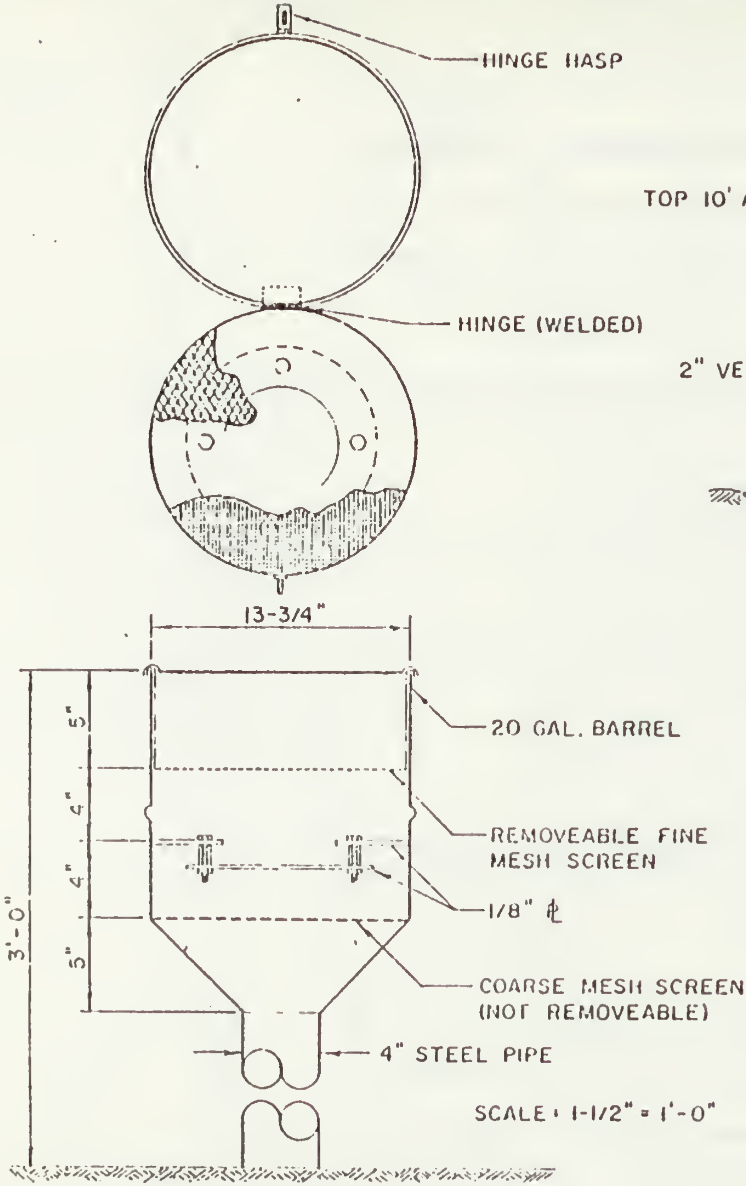
(Projected Lub/Motor Vehicles)(63%)(Projected Motor Vehicles)

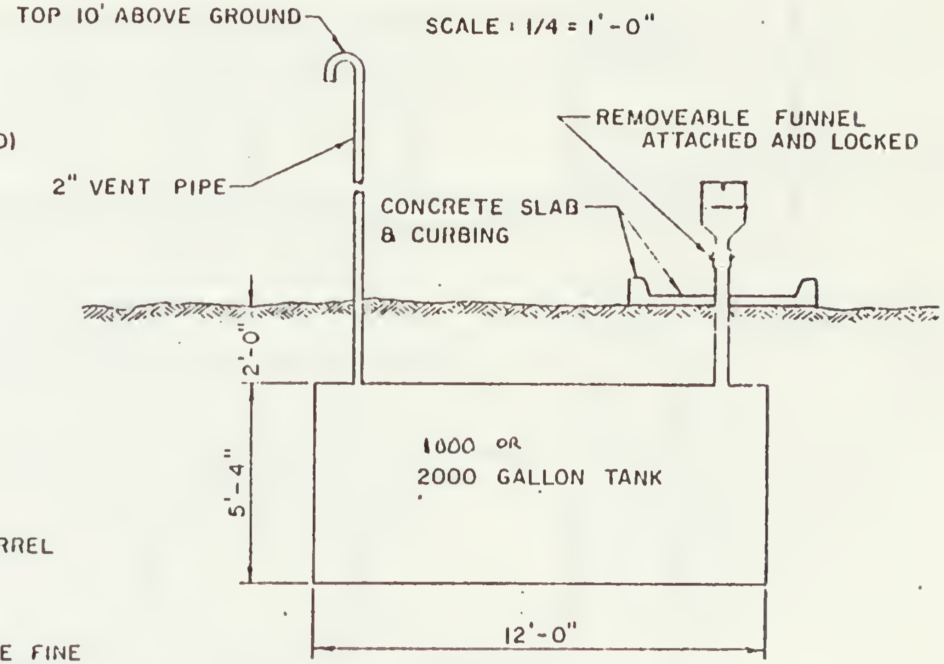


Comparison of waste oil and virgin fuel property ranges

	PROPERTY	RANGE VALUES
(f)	Neutralization Number, mg KOH/gm	0 5 10 15 20 Waste Oil Lubricants
(g)	B.S.& W, vol. %	0 5 10 15 20 25 Waste Oil Lub. No. 2 Distillate Oil No. 4 Fuel Oil No. 6 Residual Oil No. 6 Low Sulfur Residual Oil
(h)	Sulfur, wt. %	0 1 2 3 4 5 Waste Oil Lubricants No. 2 Distillate Oil No. 4 Fuel Oil No. 6 Res. Oil No. 6 Low Sulfur Residual Oil Anthracite Bituminous Sub-Bituminous Lignite
(i)	Ash, wt. %	0 6 12 18 24 30 Waste Oil Lubricants No. 2 Distillate Oil No. 4 Fuel Oil No. 6 Residual Oil No. 6 Low Sulfur Residual Oil Anthracite Bituminous Sub-Bituminous Lignite
(o)	Lead, ppm	0 4,000 8,000 12,000 Waste Oil Lubricant No. 6 Residual Oil Anthracite Bituminous Lignite

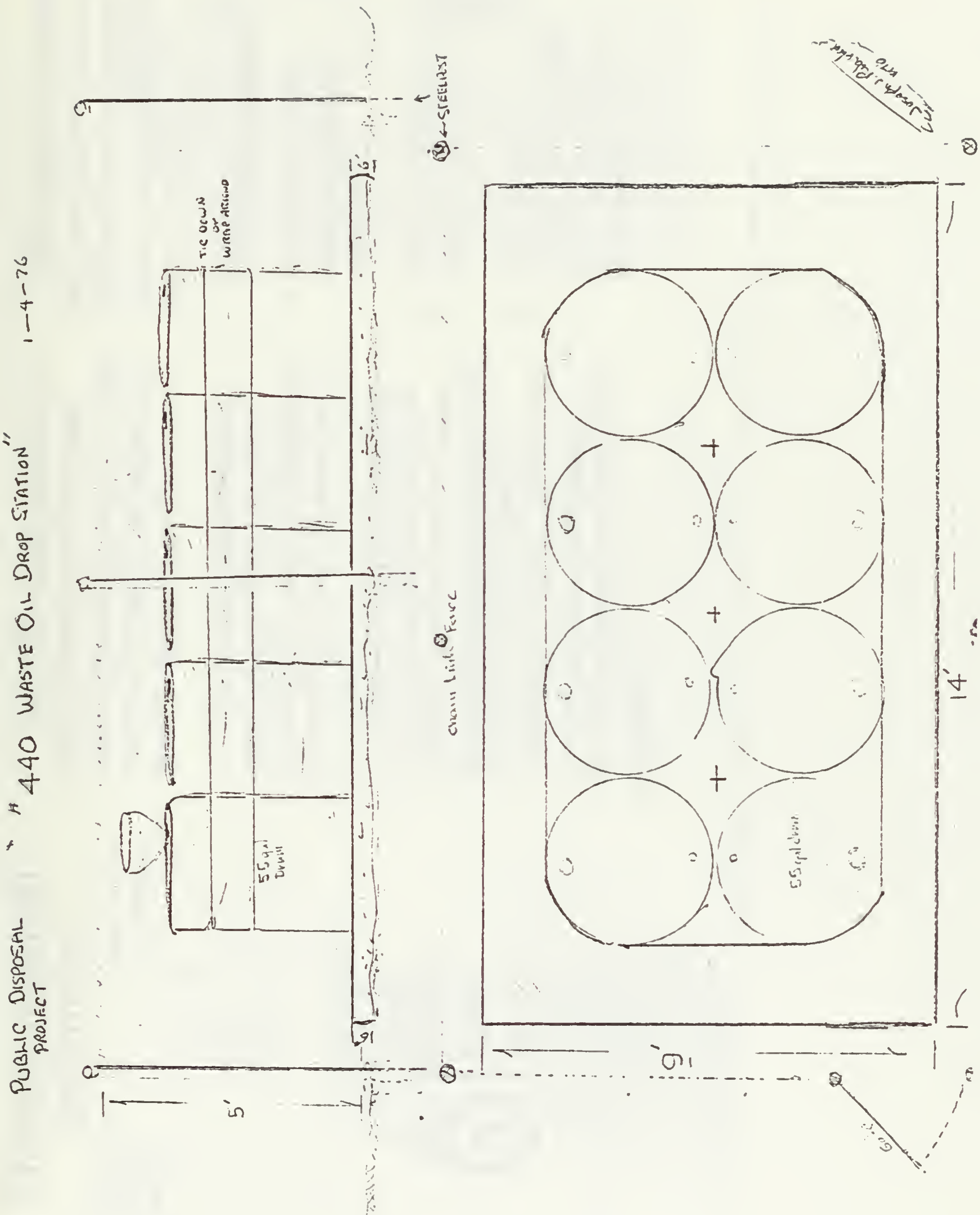
◦ WASTE OIL ◦
PUBLIC DISPOSAL TANK
1 – 4 – 76





* GUARD RAIL POSTS TO BE PLACED AROUND AREA ABOVE TANK

Joseph J. Robertson 1976


PUBLIC DISPOSAL PROJECT
#440 WASTE OIL DROP STATION
1-4-76
TIE DOWN OR WRAP AROUND
55 gal Drum
6'
STEEL POST
Chain Link Fence
5'
9'
14'
55 gal drum

This is a used oil container.

Tight fitting cap
Reusable
Leak proof

Convenient five quart capacity

Used oil—that's the kind of oil you drain out of the crank case of your lawnmower or your car on a Saturday morning. But how do you get rid of it?

In any major metropolitan area, people will dump thousands and thousands of gallons of used oil a year. Somewhere!

That causes pollution. One part of oil can foul the taste of a million parts of water. It can get into lakes and streams. And wasted oil wastes energy. Recycling it can put old oil back to work as fuel or lubricant . . . for various home and industrial purposes.

Now there is a program to help you dispose of your used oil; keep your community clean—and recycle a valuable energy resource.

What do you do?

1. Drain your used oil into a suitable container.

2. Take it where you see this symbol.

3. Then the used oil will be recycled at no cost to you . . . at no profit to us.

Your container can be emptied into temporary storage at Conoco stations or wherever you see this sign. The used oil will be picked up from temporary storage for recycling. Any income will be donated to charity.

Leave used oil here for recycling

Development costs of this program are being donated by Conoco stations (except for the reusable container shown here . . . which you may buy if you need, at cost).

CONOCO

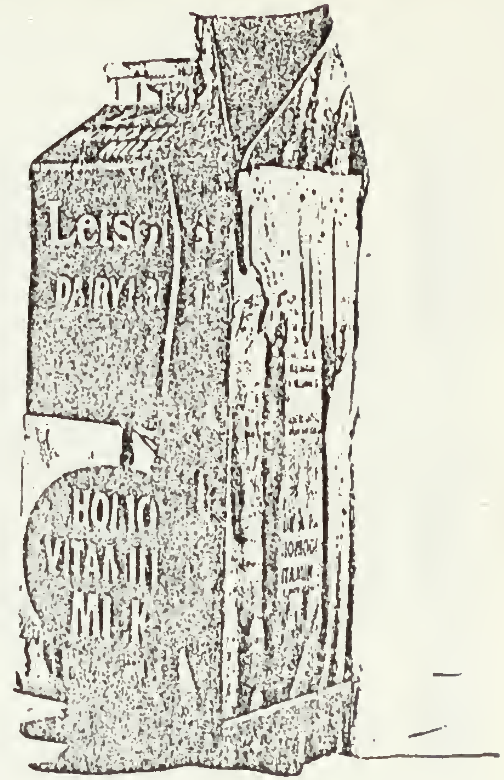
". . . crankcase oil poses the possibility of a serious threat to all living resources."—
—Environmental Protection Agency Report to the Congress.

". . . Current practices of collecting and disposing of used oils in the United States are erratic and may cause public health hazards."
—Environmental Law Institute, Washington, D. C.

Used Oil Recycling is endorsed by:

Missouri Department of Natural Resources
Kansas Department of Health and Environmental Control
Nebraska Department of Environmental Control
Iowa Department of Environmental Quality
Minnesota Pollution Control Agency

This is a milk carton.



PASSENGER CAR AUTOMOTIVE TRENDS *

YEAR	Avg. Annual Miles per Car **	Avg. Miles per Gallon**	Service Station Avg. Qts. Motor Oil per Car
1965	9,387	14.1	16.8
1966	9,506	14.0	16.3
1967	9,531	13.9	14.7
1968	9,627	13.8	12.9
1969	9,782	13.6	12.1
1970	9,978	13.6	12.0
1971	10,121	13.6	10.7
1972	10,184	13.5	10.0
1973	9,992	13.1	9.5
1974	9,494	13.5	9.5
1975	9,500	13.9	
1976	9,500	14.4	
1977	9,500	14.8	
1978	9,500	15.3	
1979	9,500	15.7	
1980	9,500	16.2	
1981	9,500	16.6	
1982	9,500	17.0	
1983	9,500	17.5	
1984	9,500	17.9	
1985	9,500	18.4	
1986	9,500	18.8	

* N.P.N. Factbook, 1976, p. 26.

** 1965-1974, U.S. Dept. of Transportation;
1975-1986, N.P.N. estimates.

COLLECTORS-WASTE OIL PICK-UP COMPANIES

KANSAS AREA

BASE	NAME	
Great Bend, Ks.	Oil Reclaiming Co. 1600 North Main (316) 458-2440 or 672-3965	Collection-Reclaiming of Industrial Oils Milton Ward, Manager Clark Stone, Owner
Kansas City, Ks.	Coral Re-refining Corporation 765 Pawnee (913) 281-5454	Re-refining only Richard O'Blasny, President Tim Tierney, V.P.
Liberal, Ks.	Panhandle Sales P.O. Box 1203 (316) 624-4441	Collection-Reclaiming Frank Tolo, Manager
Topeka, Ks.	Capital City Oil Co. 916 Adams (913) 233-8008 or 233-3084	Collection-Storage, only Frank Smith
Wichita, Ks.	Charles Wilkinson, owner (316) 682-8232	Collector for: Wichita Oil & Reclaimers and Wichita Refining Co. Collection only
Wichita, Ks.	Clearwater Re-refining (Clearwater Trucking) 5650 North Broadway (316) 832-1167	Collection-Storage-Re-refining Hap Harpster, Manager
Wichita, Ks.	Wichita Oil & Reclaimers 6416 East Central Ave. (316) 685-7401	Reclaiming-Collection John P. Reed, Owner (Nancy Sealy)
Wichita, Ks.	Wichita Refining (316) 262-2636	Sales only, no collection Gus Messinger, Manager
Denver, Colorado	Williams Refining Co. 5901 North Federal St. (303) 433-2497	Collection-Refining Lloyd Cunningham, owner

Kansas City, Mo. 64126	Radium Petroleum Co. 1633 South Marsh Ave. P.O. Box 6206 (816) 833-1919 or 833-1920	Collection and Reclaiming Ronald Deffenbaugh, owner
East Omaha, Ne.	Monarch Oil Co. P.O. Box 1257 22nd Street & Avenue "H" East	Collection-Refining Marvin Walenz, owner
Oklahoma City, Ok. 73111	Double Eagle Refining Company P.O. Box 11257 (405) 232-0244 or 232-6878	Collection-Refining Frank Kerran, owner

POSSIBLE INDUSTRIAL SOURCES

OF WASTE OIL*

DOUGLAS , FRANKLIN, and JEFFERSON COUNTIES

1. Cooperative Farm Chemicals, Lawrence
2. FMC Corporation (Inorganic Chemical Division), Lawrence
3. Fleetwood Homes of Kansas, Inc., Lawrence
4. Hallmark Cards, Inc., Lawrence
5. Kansas Color Press, Inc., Lawrence
6. Kansas Power & Light Co., Lawrence
7. Lawrence Paper Co., Lawrence
8. Packer Plastics, Inc., Lawrence
9. Stokley-Van Camp, Inc., Lawrence
10. World Publishing Co., Lawrence
11. Lawrence Transfer & Storage, Inc., Lawrence
12. The H.D. Lee Co. (Bruce Factory), Ottawa
13. Mode O'Day Corporation, Ottawa
14. Star Mobile Homes (Division Boise Cascade Corp.), Ottawa
15. Jay-Tee Co., Inc., Ottawa
16. Vinland Valley Airport, Baldwin
17. Lawrence Municipal Airport, Lawrence
18. Ottawa Municipal Airport, Ottawa
19. Dempsay Farm Airport, Rantoul

* Goltz and Weaver, 1976.